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THE MINERALOGICAL MAGAZINE

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Journal of The Mineralogical Society

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WITH A SEPARATELY-PAGED APPENDIX OF

MINERALOGICAL ABSTRACTS

EDITED BY L. J. SPENCER, F.R.S.

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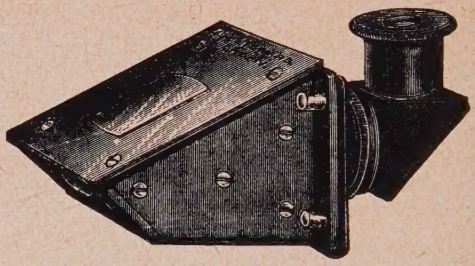

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PROCEEDINGS
OF THE
MINERALOGICAL SOCIETY

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., January 30, 1936, *at* 4.30 *p.m.*

Prof. P. G. H. Boswell, F.R.S., Vice-President, in the Chair.

Mr. Robert Walls was provisionally elected an Ordinary Member of the Society.

Reports were received from the Treasurer and the Editor.

The General Secretary gave notice that he wished to make some proposals about the accommodation of the Society's Library.

A letter was received from the Nomenclature Committee of the Mineralogical Society of America and was referred to our Nomenclature Committee.

A letter was received from the Geological Society granting permission for the use of its rooms as heretofore.

GENERAL MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., January 30, 1936, *at* 5.30 *p.m.*

Prof. P. G. H. Boswell, F.R.S., Vice-President, in the Chair.

Forty-three Members and eight Visitors were present.

The election of Mr. Robert Walls as an Ordinary Member of the Society was confirmed.

Mr. Arthur Russell exhibited specimens of withamite from the new lead in Glencoe and of almandine from Loch Garve, Ross-shire, collected in 1935.

The General Secretary exhibited small specimens in box-mounts for viewing with a binocular microscope as opaque objects.

The following papers were then read and discussed :—

1. The Morven meteorite, an aerolite from South Canterbury, New Zealand: by Mr. C. O. Hutton (communicated by Prof. W. N. Benham) (p. 265).

2. Eulysites and related rock types from Loch Duich, Ross-shire by Prof. C. E. Tilley (p. 331).

3. Gold and silver in the crystalline rocks of the Malvern Hills: b Prof. A. Brammall and Mr. D. L. Dowie (p. 260).

4. On the magnetite-plagioclase rocks of Magnet Heights, Bushvel Transvaal: by Dr. A. K. Wells.

5. The role of Al-atoms in the two reaction series: by Prof. A Brammall (p. 362).

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., March 26, 1936, *at* 4.30 *p.m.*

Sir Thomas H. Holland, F.R.S., President, in the Chair.

The following were provisionally elected Ordinary Members the Society: Vivien Lindsey Aspland, Cecil Thomas Barber, Jol Alexander Dunn, Norman Fordyce McKerron Henry, Germai Anne Joplin, Martin Alfred Peacock, and Bernard Smith.

The resignation of Mr. V. A. Eyles, received at the last meetir was accepted.

The death of Dr. George Thurland Prior on March 8, 1936, w reported. The following resolution was passed unanimously: 'Th this Society sends to Mrs. Prior its deep sympathy with her in the l occasioned by the death of Dr. G. T. Prior, for many years Gene Secretary and subsequently President of the Society, and always he in affectionate respect by his fellow members.'

The General Secretary read a report on the Society's Library present housed in the Mineral Department at the British Muse (Natural History). The report showed that the Library was pr tically not at all used by the Members apart from certain periodic used by the editor. A sub-committee was appointed consisting the General Secretary, the Editor, the Treasurer, and the Librari and it was decided to ask the Geological Society to select any bo they may wish to have, and then to offer the Geological Survey opportunity to purchase any books required by its library. The after the residue should be offered to the Members.

GENERAL MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., March 26, 1936, at 5.30 p.m.

Sir THOMAS H. HOLLAND, F.R.S., President, in the Chair.

Forty-three Members and twenty Visitors were present.

The elections of Mr. V. L. Aspland, Dr. C. T. Barber, Dr. J. A. unn, Mr. N. F. M. Henry, Miss G. A. Joplin, Dr. M. A. Peacock, nd Dr. Bernard Smith as Ordinary Members of the Society were nfirmed.

The following exhibits were explained:—

Pseudogaylussite dredged from the Clyde, from the collection of e late Prof. J. W. Gregory; linnaeite (var. carrollite) from N'Kana pper mine, Northern Rhodesia; columbite from Northern Nigeria; 5½ oz. gold nugget from Tanganyika Territory; and villiaumite m Los Islands, French Guinea: by Prof. C. G. Cullis.

The method of mounting ore-specimens for polishing in bakelite as ed by the United States Geological Survey: by Dr. F. C. Phillips.

A new rock 'enderbite' from Proclamation Island, Enderby Land, ntarctica: by Prof. C. E. Tilley.

The following papers were then read and discussed:—

1. Two new meteoric stones from South Australia—Lake Labyrinth d Kappakoola: by Dr. L. J. Spencer (p. 353).

2. Some Malvernian hornblendes; their genetic relationships: by of. A. Brammall and Mr. J. G. C. Leech.

3. The effects of heat on the optical orientation of the plagioclase spars: by Dr. C. T. Barber (communicated by Prof. C. E. Tilley) 343).

4. X-ray studies on psilomelane, pyrolusite, and hollandite: by . George Vaux.

5. Biographical notices of mineralogists recently deceased. (Sixth ies): by Dr. L. J. Spencer (p. 277).

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., June 25, 1936, *at* 4.0 *p.m.*

Sir THOMAS H. HOLLAND, F.R.S., President, in the Chair.

Prof. Vincent Charles Illing was provisionally elected a Dr. Bernard Howard Knight (resigned 1934) provisionally re-elect Ordinary Members of the Society.

The resignation of Prof. A. C. Lane was accepted, and the death May 5, 1936, of Mr. A. G. F. Gregory was reported.

The Treasurer, in the absence of the General Secretary, report on the Society's Library. A list of twelve periodicals to be retain by the Society was approved. A request for reprints was receiv from the Mineral Department of the British Museum (Natu History).

The following dates for meetings in 1937 were decided upo Thursdays, January 28, March 18, June 24, and November 4.

The list of Officers and Council for 1936–37 was considered. Th due to retire were Sir Thomas Holland (President), Sir Willi Bragg (Vice-President), and Mr. T. Crook, Dr. W. F. P. McLinto Mr. L. R. Wager, and Dr. A. K. Wells. The following were propo for submission to the Members: as President, Dr. L. J. Spencer; Vice-President, Mr. T. Crook; as Members of Council, Dr. A. Hallimond and Prof. C. E. Tilley (previous members) and Mr. B. Anderson and Mr. M. H. Hey (new members). It was agreed t Dr. Spencer should continue as editor during the coming session.

GENERAL MEETING.

Held in the Apartments of the Geological Society, Burlington Hous London, W., June 25, 1936, *at* 5.30 *p.m.*

Dr. A. E. H. TUTTON, F.R.S., Past-President, in the Chair.

Twenty-three Members and one Visitor were present.

The elections of Prof. V. C. Illing and Dr. B. H. Knight Ordinary Members of the Society were confirmed.

Mr. M. H. Hey exhibited and explained a new model of structure of edingtonite which accounted for the diffusion of wat

The following papers were then read and discussed:—

1. The paragenesis of kyanite-eclogites: by Prof. C. E. Tilley (p. 422).

2. The Tenham (Queensland) meteoritic shower of 1879 (or 1869?): by Dr. L. J. Spencer (p. 437).

3. Some unusual twin-laws observed in potash-felspars from Goodsprings, Nevada, U.S.A.: by Dr. J. L. E. Drugman.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., November 5, 1936, at 4 p.m.

Sir Thomas H. Holland, F.R.S., President, in the Chair.

The following were provisionally elected Ordinary Members of the Society: Ernest Henry Davison, William Alexander Deer, Colin Osborne Hutton, William Charles Simmons, and Robert Christopher Vance.

The deaths of Prof. Frédéric Wallerant, Honorary Member, on July 11, 1936, and of Dr. Bernard Smith on August 19, 1936, were reported. The resignation of Mr. G. L. English was accepted.

Mr. T. Crook and Mr. F. A. Bannister were appointed auditors for the accounts.

The draft Annual Report was read and approved.

A letter was received from the Royal Society containing proposals for the adoption of uniform bibliographical references and abbreviations. A sub-committee was appointed, consisting of the Editor, the General Secretary, Dr. McLintock, and Mr. Crook, to consider the proposals.

The Library sub-committee reported and recommended the presentation to the Geological Society of the books, separates, runs and old copies of periodicals asked for with only three exceptions. They also recommended the presentation of 506 separates selected by the Mineral Department of the British Museum; and reported that H.M. Geological Survey did not wish to make any purchases. A draft notice to Members advertising the books and periodicals for sale was approved.

GENERAL (ANNIVERSARY) MEETING.

Held in the Apartments of the Geological Society, Burlington House, London, W., November 5, 1936, *at* 5.30 *p.m.*

Sir THOMAS H. HOLLAND, F.R.S., President, in the Chair.

Forty-five Members and eleven Visitors were present.

Drs. A. G. MacGregor and G. F. Claringbull were appointed scrutineers of the voting-papers for the election of Officers a Council.

The elections of Messrs. E. H. Davison, W. A. Deer, C. O. Hutto W. C. Simmons, and R. C. Vance as Ordinary Members were co firmed.

The General Secretary then read the following:—

ANNUAL REPORT OF COUNCIL FOR 1935–1936.

During the session 1935 to 1936 there have been four ordinary meetings, which nine exhibits have been shown and sixteen papers read. The to attendance at the four meetings was 181, including 36 visitors.

The Council regrets to record the deaths of one honorary member, Dr. Frédé Wallerant, and three ordinary members, Dr. George Thurland Prior, a pa President of the Society, Mr. A. G. F. Gregory, and Dr. Bernard Smith. C ordinary member has resigned, and thirteen members have been elected, bring the total membership on October 31, 1936, to 243, including 7 honorary membe as against 236 in the previous year.

During the year there have been issued four numbers of the Magazine (nos. 1 154), containing 18 papers occupying 186 pages, 53 text-figures, and 5 plat also 14 pages of proceedings. Mineralogical Abstracts published with th numbers occupied 192 pages containing 619 abstracts.

The accounts for the year ending December 31, 1935, showed an excess assets over liabilities of £1250 13*s.* 5*d.* against £1247 10*s.* 4*d.* on December 1934. These assets do not include the Library and unsold stock of publicatio nor the Securities allocated to the Composition Fees Account. The value of securities standing in the names of the Trustees on December 31, 1935, w General Reserve £996 11*s.* 7*d.*, Composition Fees Account £1055 17*s.* 0*d.*, agai £990 0*s.* 8*d.* and £1081 12*s.* 7*d.* respectively on December 31, 1934.

The Society's Library has received during the year 126 parts of periodi and 4 separate copies of papers. 68 parts or volumes have been borrowed.

The Library Sub-Committee appointed by the Council in March, consistin the Editor, the Treasurer, the Librarian, and the General Secretary, to consi the future of the Society's Library, held a meeting on October 22 and issued following report:

'The Council has decided to dispose of the Society's Library as and w opportunity offers, retaining only sets of certain important mineralog periodicals. The Geological Society was invited to select such books and p

of periodicals as were required for its Library. Nineteen books and parts of sixteen periodicals were selected and have been presented. 506 separates have been presented to the Mineral Department of the British Museum (Natural History). The Council has decided that the remainder of the Library shall be offered for sale in the first place to members.'

Dr. H. von Eckermann acted as the Society's delegate at the Jubilee Celebrations of the Geological Society of Finland on October 22, and conveyed the congratulations of our Society.

The adoption of the Report having been proposed from the Chair was carried unanimously.

A vote of thanks to the Geological Society for allowing the use of its rooms was proposed by Major J. G. C. Leech and seconded by Mr. M. H. Hey and carried unanimously.

The scrutineers reported that 51 voting-papers for the Officers and Council for the ensuing year had been received and that the list nominated by the Council had been approved. The President declared these Officers and Ordinary Members of Council elected:—

President. Dr. L. J. Spencer, C.B.E., M.A., Sc.D., F.R.S.

Vice-Presidents. Prof. P. G. H. Boswell, O.B.E., D.Sc., A.R.C.S., F.R.S.

Mr. T. Crook, A.R.C.Sc.I., F.G.S.

Treasurer. F. N. Ashcroft, M.A., F.G.S., F.C.S.

General Secretary. W. Campbell Smith, M.C., T.D., M.A., F.G.S.

Foreign Secretary. Prof. A. Hutchinson, O.B.E., M.A., Ph.D., F.R.S.

Editor of the Journal. Dr. L. J. Spencer, C.B.E., M.A., Sc.D., F.R.S.

Ordinary Members of Council.

Prof. A. Brammall, Ph.D., D.Sc., F.G.S.

W. Mathews, F.G.S.

Dr. T. C. Phemister, Sc.M., Ph.D.

J. Broughton Edge, M.B.E., A.R.S.M., F.G.S.

Prof. H. H. Read, D.Sc., F.G.S.

Arthur Russell, M.B.E.

C. Spiller, M.A.

Dr. Gilbert Wilson, Ph.D., M.Sc., F.G.S.

Dr. A. F. Hallimond, M.A., Sc.D., F.G.S.

Prof. C. E. Tilley, B.Sc., Ph.D., F.G.S.

B. W. Anderson, B.Sc., F.C.S.

M. H. Hey, M.A., B.Sc., F.C.S.

The retiring President (Sir Thomas Holland) thanked Members for their good attendance, and welcomed Dr. L. J. Spencer to the Chair.

[*continued on p. lxviii*

MINERALOGICA

ABSTRACT OF RECEIPTS AND PAYMEN

GENERAL PU

Receipts.	£	s.	d.	£	s.
By Balances brought forward from 1935—					
1. At Bankers:					
(*a*) Current Account	12	9	6		
(*b*) Deposit Account	200	0	0		
2. In Office	0	1	0		
				212	10
Entrance Fees				13	13
Annual Subscriptions—					
1. Current year	184	16	0		
2. Arrears	5	8	0		
3. Advance	10	14	0		
				200	18
Sale of Publications—					
1. By Publishers, April 1, 1935–March 31, 1936. Sales at subscription rate £270 15*s.* 0*d.* and other sales £47 19*s.* 0*d.*, less trade discount and commission £87 19*s.* 1*d.*, and distribution charges £17 13*s.* 9*d.*	213	1	2		
2. By Custodian of Stock, 1936. £48 0*s.* 6*d.*, less distribution charges £1 7*s.* 8*d.*, and cost of back numbers purchased £3 12*s.* 0*d.*	43	0	10		
				256	2
Advertisement Fees, £19 12*s.* 4*d.*, less commission £3 18*s.* 5*d.*				15	13
Interest on Investments as received–					
1. £640 3½% War Loan 1952 and after, Inscribed Stock	22	8	0		
2. £105 4% Consolidated Loan 1957, Inscribed Stock	4	4	0		
3. £100 4% Funding Loan 1960–90, Inscribed Stock	4	0	0		
4. £140 Metropolitan Water Board 3% 'B' Stock, Inscribed	1	17	11		
				32	9
Income Tax recovered				0	2
Deposit Interest				1	16
Small Receipts				0	2
Transfers from other accounts—					
From Composition Fees Account, being Interest on Investments				34	19
				£768	7

SOCIETY

FOR THE YEAR ENDING DECEMBER 31, 1936

POSES ACCOUNT

Payments.	£ s. d.	£ s. d.
Printing and distributing the Mineralogical Magazine Nos. 152–155 inclusive (Oxford University Press)—		
1. Printing	284 4 6	
2. Illustrations	38 18 0	
3. Authors' Separate Copies	26 15 0	
4. Distribution Charges	13 10 6	
		363 8 0
Printing and distributing Notices of Meetings and other annual miscellaneous printing		16 4 0
Miscellaneous Printing, &c. (not annual)—		
1. Treasurer's Notices	2 11 6	
2. Secretary's Notices	0 17 6	
		3 9 0
Expenses at Meetings—		
1. Operator of lantern	2 2 0	
2. Porter	1 0 0	
3. Tea	4 3 6	
		7 5 6
Care of Stock of Publications, J. Mugford, Annual Fee		1 1 0
Editor's Honorarium		50 0 0
Librarian's Honorarium		5 0 0
Postage—		
1. Hon. Secretary	0 18 6	
2. Editor	1 3 6	
3. Librarian	0 0 10	
4. Hon. Treasurer (not charged)	0 0 0	
		2 2 10
Bank charges, Cheque Book, and other small items		0 12 10
Investments—		
Purchase of £89 12*s.* 0*d.* Metropolitan Water Board 3% 'B' Stock, Inscribed		88 18 11
Balance, December 31, 1936—		
1. At Bankers:		
(*a*) Current Account	34 16 7	
(*b*) Deposit Account	195 0 0	
2. In Office	0 8 11	
		230 5 6
		£768 7 7

Examined and compared with Vouchers and found correct.

F. A. BANNISTER } Auditors.
GILBERT WILSON }

January 14, 1937.

F. N. ASHCROFT, Hon. Treasurer.

BALANC

DECEMB

LIABILITIES.	£	s.	d.	£	s.
To Annual Subscriptions received in advance—					
1. Received in 1936 for 1937	9	13	0		
2. Received in 1936 for 1938	1	1	0		
				10	14
Excess of Assets over Liabilities				1363	18
				£1374	12

COMPOSITION FEES ACCOUI

RECEIPTS.	£	s.	d.	£	s.
By Composition Fees received as per last Account .	1149	15	0		
Composition Fee received during year . . .	15	15	0		
				1165	10
Income—					
1. Interest on Investments as received—					
1. £975 3½% War Loan 1952 and after, Inscribed Stock	34	2	6		
2. £10 4*s.* 8*d.* 3% Conversion Loan 1948–53, Inscribed Stock	0	6	0		
3. £26 14*s.* 0*d.* Metropolitan Water Board 3% 'B' Stock, Inscribed	0	10	0		
2. Income Tax recovered	0	1	2		
				34	19
				£1200	9

HEET

, 1936.

Assets.	£ s. d.	£ s. d.
Balances—		
1. At Bankers:		
(*a*) Current Account	34 16 7	
(*b*) Deposit Account	195 0 0	
2. In Office	0 8 11	
		230 5 6
Sundry Debtors—		
Publishers (Oxford University Press):		
(*a*) For sales of Publications, April 1–Dec. 31, 1936	74 4 0	
(*b*) For advertisement Fees, April 1–Dec. 31, 1936	13 3 6	
		87 7 6
Investments at Broker's Valuation—		
1. £640 3½ % War Loan 1952 and after, Inscribed Stock, at 105½ %	675 4 0	
2. £105 4 % Consolidated Loan 1957, Inscribed Stock, at 112⅞ %	118 16 4	
3. £100 4 % Funding Loan 1960–90, Inscribed Stock, at 116¼ %	116 5 0	
4. £140 Metropolitan Water Board 3 % 'B' Stock, Inscribed, at 99 %	138 12 0	
		1048 11 4
Annual Subscriptions in arrear (£9 9*s.* 0*d.*) estimated to realize		6 6 0
Entrance Fees in arrear		2 2 0
		£1374 12 4

NOTE.—The value of the Library, that of the unsold Stock of Publications, and the Securities allocated to the Composition Fees Account are not included in the above assets.

January 14, 1937. F. N. ASHCROFT, Hon. Treasurer.

EAR ENDING DECEMBER 31, 1936

Payments.	£ s. d.	£ s. d.
Investments as per last Account—		
1. £975 3½ % War Loan 1952 and after, Inscribed Stock, valued by Brokers at £1028 12*s.* 6*d.* (105½ %), at cost	1128 15 0	
2. £10 4*s.* 8*d.* 3 % Conversion Loan 1948–53, Inscribed Stock, valued by Brokers at £10 11*s.* 6*d.* (103⅜ %), at cost	10 10 0	
3. £26 14*s.* 0*d.* Metropolitan Water Board 3 % 'B' Stock, Inscribed, valued by Brokers at £26 8*s.* 8*d.* (99 %), at cost	26 5 0	
		1165 10 0
Income transferred to General Purposes Account		34 19 8
		£1200 9 8

Examined and compared with Vouchers and found correct.

F. A. BANNISTER } Auditors.
GILBERT WILSON }

January 14, 1937. F. N. ASHCROFT, Hon. Treasurer.

A vote of thanks to the retiring President, Vice-Presid (Sir William Bragg), and Ordinary Members of Council (Dr. W. F. McLintock, Mr. L. R. Wager, and Dr. A. K. Wells) was proposed Prof. W. G. Fearnsides and seconded and was carried unanimousl

Prof. C. E. Tilley exhibited pyroxmangite- and rhodonite-beari schists from the Lewisian of Glenelg; Dr. A. T. J. Dollar an in grating stage for micrometric analysis; and Mr. Arthur Russell spe mens of kyanite, zoisite, and garnet from Scotland.

The following papers were then read and discussed :—

1. Demonstrations in petrogenesis from Kiloran Bay, Colonsay. The transfusion of quartzite : by Miss D. L. Reynolds (with analy by Agnes Gibbs and others) (p. 367).

2. Transfusion of quartz xenoliths in alkali basic and ultraba lavas, south-west Uganda : by Prof. Arthur Holmes (p. 408).

3. An occurrence of greenalite-chert in the Ordovician rocks of t southern uplands of Scotland : by Dr. W. Q. Kennedy (p. 433).

4. The composition and paragenesis of the biotites of the Carspha igneous complex : by Mr. W. A. Deer (communicated by Prof. C. Tilley) (p. 495).

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The Tenham (Queensland) meteoritic shower of 1879.

(With Plates XIV–XVII.)

By L. J. Spencer, C.B.E., B.Sc., M.A., Sc.D., F.R.S.
Formerly Keeper of Minerals in the British Museum.

[Read June 25, 1936.]

VERY little information can now be gathered about a remarkable shower of meteoric stones that fell many years ago in a remote district in south-west Queensland. Only a few scraps of information have appeared in print, and these are largely contradictory. However, some very tangible evidence arrived unexpectedly at the British Museum in 1935 in the form of a remarkable collection of 22 complete meteoric stones with a total weight of 107¾ lb. This material had been in the possession of Mr. Benjamin Dunstan,[1] formerly Government Geologist of Queensland, who had been collecting information of the fall with a view to writing up an account for publication. This unfortunately he never did, and much of the information is now lost. The specimens were offered to the British Museum by his widow, but they came along quite casually as an appendix to a collection of fossils. With their appearance of ugly, black, and shapeless stones, they had run a chance of being overlooked and perhaps eventually lost, as has so often happened with private collections. Now they are carefully preserved and exhibited, and it is proposed to keep the set intact as an example of a unique shower.

[1] Benjamin Dunstan (1864–1933). Obituary notices in Queensland Government Mining Journal, 1933, vol. 34, p. 276, with portrait; Min. Mag., 1936, vol. 24, p. 284.

Mrs. A. M. Dunstan has since carefully searched through her la husband's papers and has kindly sent a map, photographs, certifica of chemical analysis, and various scrappy notes. Dr. H. C. Richar Professor of Geology and Mineralogy in the University of Queenslar has also kindly made various inquiri_s and supplied some detai An inquiry by post to the place of fall brought no reply. The f happened so long ago that a special visit to the remote locality seem too unpromising to be undertaken. Fortunately, however, I was la able to get in touch with Mr. Michael Hammond, who at the age nearly 15 witnessed the fall in 1879. He has very kindly dictat his memories in a letter dated September 19, 1936, and this accou clears up some, though not all, of the doubtful points.

Below is collected together such information that has alrea appeared in print.

'Queensland Times', published at Ipswich, Queensland, Augu 1911:

The Tenham Meteorites. Interesting specimens.—One night in February, 18 Mr. M. Hammond, owner of Tenham Station, was camped with his broth whilst mustering cattle, near the junction of Cooper and Kyabra Creeks in sou west Queensland. The darkness was suddenly illuminated as if by a lightn flash, a noise like a rushing motor-car was heard, and upon looking up the broth beheld a brilliant meteoric shower passing from west to east. Soon afterwa the locality in which the meteorites fell was found, and from time to time a num of specimens were collected, the largest weighing 130 lb.

Twelve months ago Mr. Hammond told Mr. R. A. Wearne, B.A., Principal the Ipswich Technical College, about these meteorites, and upon being urged give publicity to such an important discovery, he promised to bring them Brisbane at the first opportunity. On the 8th of July ultimo Mr. Hamm fulfilled his promise and brought a number of the meteoric fragments with l to Brisbane. A photo of the meteorites was taken at the Wiley Studio, and collection was then handed to Mr. Wearne for distribution. Mr. Wearne t interviewed Mr. MacDonald of the University Department of Mines and Mr. D stan, Government Geologist, and arranged to have analyses made of these m interesting extra-terrestrial rocks. The complete analyses are not yet to ha but preliminary tests show that the Tenham meteorites are of the stony vari but contain a somewhat large percentage of nickel and iron. Small stony enclosures can be seen between the bright metallic patches upon a polis surface. The specific gravity of the specimens averages about 3·5.

Queensland Government Mining Journal, August 15, 1913, vol. p. 404:

Queensland Meteorites.—The Mines Department has recently come into pos sion, through Mr. A. R. Wearne, of Ipswich, of a number of meteorites that fe Western Queensland in 1879. They were presented by Mr. M. Hammond Tenham Station, Cooper's Creek, who lately brought from that place a ba

the specimens. Mr. Hammond, thirty-four years ago [i.e. 1879], was an eye-witness of the storm during which these meteorites fell, when he, with his brother, was one night watching cattle at the junction of Kyabra and Cooper's Creeks, near Windorah. The storm covered an area of about half a mile, and some of the meteorites descended on a ridge of the adjacent range, and some on the plains. On the following day some of them were found on the surface and others embedded 2 ft. or more in the ground, the largest discovered being about 130 lb. in weight. They all have a metallic appearance. The Government Geologist (Mr. B. Dunstan) intends to thoroughly examine and have assays made of the specimens in his possession and publish a full description of them later. He states that they contain nickel-iron, the proportion of the former being large. Cobalt and manganese gave no reactions, so that if these metals are present they will be only in minute traces.

B. Dunstan, Queensland Mineral Index and Guide Queensland Geological Survey, publication no. 241, 1913, p. 718:

Meteorites.—Tenham stones (15). Weights vary from 20 to 5241 grammes. *Loc.* Tenham Station, junction of Cooper and Kyabra Creeks, Western Queensland. Lat. 25° 30′ S., *Long.* 142° 40′ E. *Compo.* Mostly silicates, with a few per cent. of nickel-iron. *Sp. gr.*, 3·4. *Fall*, about Feb. 1879, between 2 and 3 o'clock in the morning, and apparently coming from west to east. *Observer*, P. Hammond, of Tenham Station. *Collections*: Geol. Survey Museum and Queensland University.

G. T. Prior, Appendix to the Catalogue of Meteorites, British Museum, London, 1927, p. 43:

Tenham, South Gregory, Queensland. Stone. Fifteen stones fell (?) in Lat. 25° 30′ S., Long. 142° 40′ E. (G. W. Card's MS. list of Australian meteorites, in Min. Dept., British Museum).

This information given in a letter from Mr. G. W. Card in 1925 is evidently derived from Dunstan's publication of 1913, which had escaped Dr. Prior's notice. There is no mention of the Tenham meteorite in Dr. C. Anderson's list of 1913.[1] Copying from Prior, it is listed by H. H. Nininger in 'Our stone-pelted planet' (Boston and New York, 1933, p. 231).

H. C. Richards in 1930 in his description of the Glenormiston meteorite gives a list of known Queensland meteorites; Mem. Queensland Museum, 1930, vol. 10, p. 66 [Min. Abstr., vol. 4, p. 426]:

An undescribed collection of 102 fragments of various sizes and aerolitic in character which were seen to fall on Tenham Station near the junction of Cooper and Kyabra Creeks, in south-western Queensland, in the year 1869, by Mr. M. Hammond and his brothers.

I have had an opportunity of discussing with Professor Richards the discrepancy in the record of the date of fall. He was personally

[1] C. Anderson, A catalogue and bibliography of Australian meteorites. Rec. Australian Museum, 1913, vol. 10, pp. 53–76.

acquainted with the late R. A. Wearne, who wrote the newspap article in 1911, and he thinks that 1869 must be the correct da On the other hand, B. Dunstan in 1913 gave 1879, and this da also occurs in his MS. notes, which Mrs. Dunstan thinks must correct. In the library of the London offices of the Agent-Gene for Queensland I have been able to trace the history of the Hammo family. Michael Hammond was born on May 1, 1864, the young son of James Hammond, who took up his first block of land in 18 naming it Tenham after his birth-place (Teynham) in Kent, Englar Michael afterwards became the owner of the Tenham Station 350 square miles, which at one time was the farthest west wh settlement in south-west Queensland. It his letters of September and 19, 1936, Mr. Michael Hammond is quite definite about the y being 1879 (and not 1869), but he now gives the month as eitl March or April.

The Tenham head station or homestead is situated on the left ba of the Kyabra Creek, thirty miles SE. of the post-town of Windor in Gregory South district. It is at lat. 25° 44′ S., long. 142° 57′ On a tracing, evidently from the pastoral map (2 miles to 1 in Mr. Dunstan marked approximately the area over which meteo stones were found. This track (text-fig. 1) has a length of 41 mi and a width of about 3 miles. Its western end is at about 25° 30′ 142° 40′ E. (the latitude and longitude given by Dunstan in 19 and repeated by Prior). On the Map of Queensland (16 miles 1 inch) issued by the Surveyor-General in 1895, and used for t Geological Map in 1899, this locality is in Gordon County. At a la date there was a further subdivision of counties (see, e.g., plate 18 Dunstan's Mineral Index, 1913; and 'The Times' Atlas, 1922); a Tenham homestead was then in Kyabra county, while the meteor track was mainly in Thunda county, only just touching Kyabra a Grey counties. These county divisions have again now beco obsolete. The locality is now in the Land Agent district of Char ville, and the post-town is Quilpie.

Mr. M. Hammond also tells me that the boundaries have b greatly changed. In 1901 with his brother-in-law he took up holding 'Ingella' in the same district. As most of the meteori fell on this area he now wishes to change the name of the fall fr 'Tenham' to 'Ingella'. But as the latter name was not on the m in 1879 (nor on any map now available to me) such a change is clea not advisable.

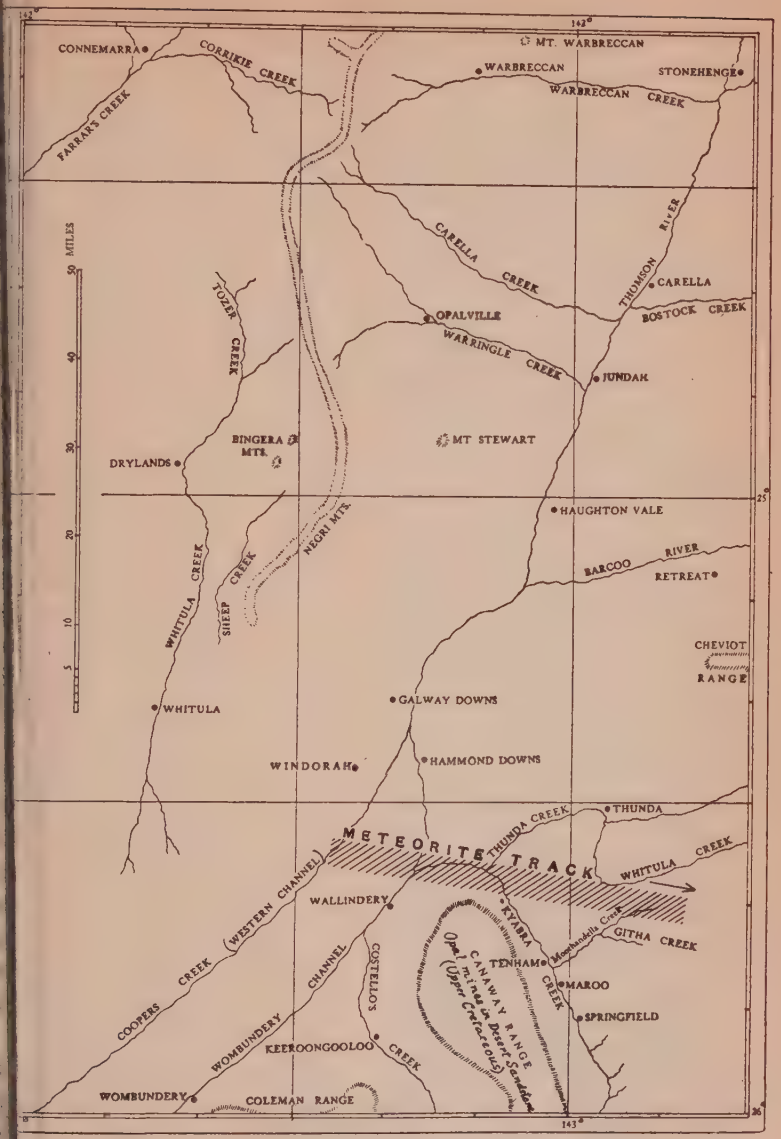


FIG. 1. Sketch-map of locality of the Tenham meteoritic shower, south-west Queensland. The 'meteorite track', about 41 miles in length, is copied from Dunstan's sketch (1913) and is open to some doubt. Mr. M. Hammond (1936) gives the length as approximately 12 miles.

There are also serious discrepancies in the statements of the numbe and weights of the stones. Wearne (1911) says a 'number of spec mens', and gives the weight o the largest as 130 lb. Dunsta (1913) mentions fifteen stone ranging in weight from 20 t 5241 grams. Richards (193(mentions 102 'fragments'. MS. note dated June 27, 191: gives a list of Dunstan's fiftee specimens with their weigh and specific gravities, as fo lows:

Fig. 2. 98 stones of the Tenham meteoritic shower. × $\frac{1}{10}$.

No.	Grams.	Sp. gr.
1.	5241·9	3·46
2.	5146·8	3·40
3.	3637·0	3·40
4.	1964·1	3·48
5.	1840·0	3·39
6.	889·1	3·39
7.	714·7	3·39
8.	335·0	3·37
9.	221·2	3·41
10.	207·3	3·37
11.	82·4	3·41
12.	61·9	3·44
13.	60·6	3·42
14.	58·2	3·38
15.	20·7	3·41

Some of these pieces we sliced and polished, and us for making micro-sections; a the weights do not quite corr spond with those given in t longer list below. Further, t values for the specific gravit were in several cases later co rected, and the work was ev dently done by an inexperienc assistant.

Early in 1935, 98 stones (te fig. 2), nearly all of them complete individuals, were received at t British Museum from Mrs. Dunstan. Each of them is marked wi

painted number T1 to T100. Nos. 5 and 13 are missing, although ese appear in the photographs (unfortunately not dated) taken by e Department of Agriculture and Stock at Brisbane (pls. XIV–XVI). ater on in 1935 Mrs. Dunstan found and sent four more small ecimens, which are entered below under nos. 101–104. These 102 ecimens are listed below with their weights as determined by

Tenham meteorites in the British Museum collection.

o.	Grams.	No.	Grams.	No.	Grams.	No.	Grams.
1	5245	T 27	466	T 53	218	T 79	118·7
2	5160	28	457	54	213·5	80	110
3	4290	29	447	55	211	81	111·7
4	3645	30	440	56	206·2	82	98·7
—	—	31	426·2	57	204	83	95
6	1903	32	414·5	58	203	84	88·7
7	1497	33	404	59	192	85	88·2
8	1124	34	399·5	60	191·5	86	87·9
9	997	35	366·7	61	188	87	77·4
0	889	36	365	62	184·5	88	77·4
1	766	37	351	63	176·5	89	68·2
2	734	38	335	64	173	90	58·4
—	—	39	327·5	65	178·5	91	50
4	736·5	40	312	66	167·7	92	45·5
5	717·5	41	311	67	167	93	43·7
6	714	42	307	68	165·2	94	43
7	633	43	307·2	69	162·5	95	37
8	637	44	275·5	70	153	96	30·9
9	636	45	267·7	71	129·2	97	30
0	619	46	258	72	140	98	25·2
	619·4	47	249·5	73	140·5	99	20·7
	589·5	48	246·7	74	138	100	17·5
	518·5	49	241·5	75	128·9	101	98·7
	511·5	50	234	76	124·8	102	88·7
	468·5	51	228	77	124·7	103	77·4
	502·7	52	226	78	118·2	104	77·4

. A. F. J. May of the Mineral Department of the British Museum. e total weight amounts to 48,982 grams = 107¾ lb. The largest 5245 grams = 11½ lb.

The missing no. 5 to judge from the photographs (pl. XIV) is much aller than no. 4 and no bigger than no. 6, and it probably is no. 5 Dunstan's list of specific gravities, with a weight of 1840 grams. e missing no. 13 must have weighed about 735 grams, to judge m the sequence in the list. The total weight of the 104 stones uld then be 51,557 grams = 113½ lb.

A chemical analysis of the material was made in the Government

Chemical Laboratory at Brisbane, and fortunately the certifica dated September 30, 1913, has been preserved. The material v crushed and sieved through an 80-mesh sieve and separate analy were made of the coarser and finer portions. These two portions, shown by the original figures under I and II. correspond roughly the metallic and silicate portions of the meteorite. They weigh

Analysis of the Tenham meteorite (I–III).

		I.	II.			III.	IV.	V
Fe	...	83·8	20·2	Fe ...	....	7·43	7·70	6·
Ni	...	11·8	0·9	Ni ...	...	1·05	1·19	1·
Co	...	1·2	trace	Co	...	0·02	0·04	0·
Mn	...	—	0·4	FeS	...	5·0	6·79	6·
SiO_2	...	1·5	38·4	SiO_2	...	37·8	39·64	39·
Al_2O_3	...	—	1·9	Al_2O_3	...	1·9	2·40	1·
MgO	...	—	25·3	FeO	...	13·6	13·99	12·
CaO	...	—	1·9	MnO	...	0·5	trace	0·
S ...	...	—	1·8	MgO	...	24·9	24·71	24·
P ...	....	—	0·3	CaO	...	1·9	1·79	2·
&c.	...	1·7	8·9	P_2O_5	...	0·7	0·25	0·
		100·0	100·0	&c.	...	5·2	1·90	4·
						100·0	100·40	100·

I–III. Tenham, SW. Queensland. Analysis made in the Government Chem Laboratory, Brisbane. I, coarse portion, 0·46 gram. II, fine portion grams. The difference ('&c.') stated as 'oxygen and undetermined'. Cr, As nil. III, calculated bulk composition.

IV. Baroti, India. '&c.' includes TiO_2 0·16, Fe_2O_3 0·44, Cr_2O_3 0·18, Na_2O 0 K_2O 0·04, H_2O 0·17. G. T. Prior, Min. Mag., 1914, vol. 17, p. 134, 1913, vol. 17, p. 26.

V. Warbreccan, SW. Queensland. '&c.' includes TiO_2 0·21, Fe_2O_3 2·15, Cr 0·41, NiO 0·12, Na_2O 0·92, K_2O 0·06, H_2O 0·80. G. T. Prior, Min. M 1916, vol. 18, p. 8.

0·46 and 30 grams respectively, which, if the separation had b complete, would correspond to a metallic content of 1·5 %. nickel 0·9 % shown in column II, however, no doubt belongs to metallic portion. With this assumption, and taking the ratio Fe : Ni = 7·1 : 1 from a column I, the bulk composition has b calculated as given under III. The molecular ratio MgO : FeO 3·3 : 1. This composition is strikingly similar to those of the Ba (India, fell September 15, 1910) and Warbreccan (SW. Queensla meteoric stones, which are quoted for comparison.

The general appearance of the stones is well illustrated in pls. x xvi, and text-fig. 3. The shapes are irregular, and the surfaces smo

without any very prominent 'thumb-marks'. Except for four specimens that have been cut and polished, they are all complete stones with the crust broken in only a few small places. The surface sculpturing gives no definite indications of orientation of the stones during their flight. The colour varies from black to reddish-brown. A note by Mr. Dunstan states that this difference in colour is due to the stones

Fig. 3. Tenham meteorite. The second largest stone (T 2); weight 5160 grams. ½ nat. size.

ing in black or red soil. But more probably the brown colour is due o oxidation. The specific gravity of one stone weighing 43·1281 grams as determined by Mr. S. E. Ellis in the Mineral Department of the ritish Museum to be 3·46. Mr. Dunstan's values listed above range om 3·37 to 3·48.

Polished surfaces show a sprinkling of small white metallic particles nickel-iron with irregular outlines (pl. xvii, fig. 2), which occupy ss than 5 % of the total area, but varying in amount in different ones. Small bronze-coloured grains of troilite are less frequent. ne stony portion (pl. xvii, fig. 1) shows much brecciation, with nite and pale yellow fragments representing broken chondrules set a darker grey ground. Well-defined chondrules up to 5 mm. ameter are sometimes seen. On some sections narrow black veins

are seen. These cut through both the matrix and the broken chon drules.

Micro-sections show much fragmentary and iron-stained materia with larger fissured crystals of olivine, and a few broken chondrul of fibrous enstatite and of porphyritic olivine. The black crust irregular, with a maximum thickness of ½ mm. This is the commone type of meteoric stone, and may be described as a brecciated ar veined enstatite-olivine-chondrite; and the chemical analysis shov it to be of the Baroti type.

This remarkable series of specimens from the Tenham shower is tl best and most complete example of a meteoritic shower in the Briti Museum collection of meteorites. The Pultusk (Poland) shower January 30, 1868, when it is estimated that a hundred thousa stones fell, is represented in the collection by 72 stones with a tot weight of 18,188 grams, the largest stone weighing 9095 gra (20 lb.). The Holbrook (Arizona) shower of July 19, 1912, wh fourteen thousand stones fell, is represented by 99 stones with a tot weight of 7783 grams, the largest weighing 3120½ grams and t smallest 0·329 gram. The Tenham shower is represented by 102 ston with a total weight of 48,982 grams (107¾ lb.).

A large stone of 130 lb., mentioned in 1911 and 1913, is aga referred to in Mr. M. Hammond's letter of 1936. He says: intended presenting two large meteorites, but unfortunately t largest mass was misappropriated from my possession by an opal buy by name R. Pope. The weight of this stone should have exceed 140 lb.' Now, it is a most remarkable coincidence that two lar stones, said to be from this same region, were acquired for t British Museum collection in 1905 through the well-known op dealer T. C. Wollaston of Adelaide, who had them from R. Po These are the 'Warbreccan' stones weighing 69 and 64 lb. (31,5 and 29,140 grams), and also a small stone of about 1 lb. (443 gram The description of these stones was delayed until 1916, partly becau the information supplied with them was not altogether convincin They were stated to have been found in 1904 on 'Warbreccan ru Dr. G. T. Prior gave the locality, first as 'about 40 miles west Windorah',[1] and later as 'about 40 miles NW. of Windorah'.[2] T former statement was taken from a rough sketch-map supplied by Pope; and the latter appears to have been based on the position

[1] G. T. Prior, Min. Mag., 1916, vol. 18, p. 7.

[2] G. T. Prior, Catalogue of Meteorites, British Museum, 1923, p. 189.

Warbreccan run' as marked on Map 15 of the Queensland volume 'The new Atlas of Australia' by John Sands, Sydney, 1886. 'Warbreccan run' I find on no later map. In the early days of ttlement it no doubt extended for an indefinite distance from the Varbreccan head station (cf. this vol., p. 14). On the Surveyor-eneral's maps of 1885 and 1895 Warbreccan is in Musgrave county, itchell district, at about 80 miles north by east of Windorah (text-. 1). Later maps (B. Dunstan, 1913; 'The Times' Atlas, 1922) ow it in Warbreccan county. A point 40 miles west of Windorah s between Whitula and Canterbury, and one 40 miles NW. of indorah is near Drylands; all of which are on the 1885 and 1895 aps. This rather suggests that in 1904 R. Pope was inventing a ory. An interesting sidelight in his letters is that he failed to find big fellow' said by the aboriginals to be covered by flood water. M. Hammond (1936) also mentions a gigantic stone, 'too large move' seen by the aboriginals in a swampy area about two miles m the present Ingella homestead. This he was never able to find.

The three Warbreccan[1] stones have the same general appearance those of the large series of Tenham stones. In thin sections under microscope they show the same characters, and the chemical alyses (p. 444) are essentially identical. There seems, therefore, le doubt that the 'Warbreccan' stones really belong to the nham shower. The only difficulty is that there are two stones ghing together 133 lb., instead of one of about 130 lb.; but this y be due to a lapse of memory on Mr. Hammond's part, with haps some confusion with the Thunda siderite of 137 lb. found in same district (p. 451). Mr. Hammond informs me that he still 36) has over 100 lb. of the Tenham stones in his possession. luding these and the Warbreccan stones (134 lb.), the total weight tones recovered from the Tenham shower is about 350 lb. In this y thinly populated district it is probable that many more stones e never found. The total weight of stones preserved from the tusk (Poland) shower is given by Wülfing[2] as 200,932 grams 2 lb.).

Meteoritic showers.

howers of meteoric stones have evidently been produced by the aking up of a single large mass of friable material in the earth's osphere. While showers of usually only a few stones are not

[1] G. T. Prior, Min. Mag., 1916, vol. 18, plates I and II.
[2] E. A. Wülfing, Die Meteoriten in Sammlungen. Tübingen, 1897, p. 287.

infrequent, showers of siderites are very exceptional. Striking examp are those of Bethany (Gibeon) in South-West Africa, where 51 mas of meteoric iron with a total weight of 15 tons have been collecte and Henbury (Central Australia) where thirteen craters were forme A shower of three small siderites fell at Samelia in Rajputana 1921. Siderites are generally larger than stones, and in several ca very much larger. The largest recorded single stone is Paragou (Arkansas, fell 1930) of 820 lb.; and the largest in the Brit Museum collection is Parnallee (Madras, fell 1857) of 133½ lb. T record size for a siderite is the Hoba (South-West Africa), estima to weigh 60 metric tons, or, allowing for the enveloping iron-sha originally nearly a hundred tons.[2] Being fragile and friable, sto are more liable to be broken than the tough and coherent siderite

A meteorite entering the earth's atmosphere with a relative veloc of 20 to 40 or more miles per second meets with an enormous resistance, and with the friction a high temperature is soon develop The surface is melted, and this molten material will be swept off the rush of air as quickly as it is formed; thus producing the tr of shooting stars and fireballs. As shown by the very narrow heat zone, even in the better conducting siderites,[3] this ablation of mater must have proceeded as fast as the conduction of heat into the inter of the mass. Small masses are entirely dissipated in the atmosphe to fall as cosmic dust. Only siderites can burn, since the stones (ap from the metal and troilite they contain) are already fully oxidiz as silicates. The silicates would no doubt be vaporized, to conde again as dust. Only a really large mass could leave a remnant reach the ground, and this would probably be but a small fracti of the original size.

Incandescence may commence at a height of about a hundred mil As denser layers of the atmosphere are reached the increasing pressure is sufficient to burst a friable stony mass, which may alrea have been cracked by the sudden change in temperature. The seve fragments, scattered by the explosion, continue on their course. W the greater surface now exposed still more material is swept off, a a complete crust is formed on each piece. With detonating fireba

[1] The numerous smaller masses of iron found scattered around the Henb craters and around the single crater at Canyon Diablo, Arizona, resulted fr the breaking up of the larger mass by the gaseous explosion that formed crater.

[2] L. J. Spencer, Min. Mag., 1932, vol. 23, p. 7.

[3] Ibid., 1935, vol. 24, p. 16.

more than one detonation is often heard; there being second or third bursts as the fragments from the first burst reach denser layers of air. These several bursts may sometimes be traced in the character of the crust on the different surfaces of a fallen stone. The latest fractured surfaces may be only just singed, indicating that the velocity of the mass had been so checked by the air resistance that a correspondingly

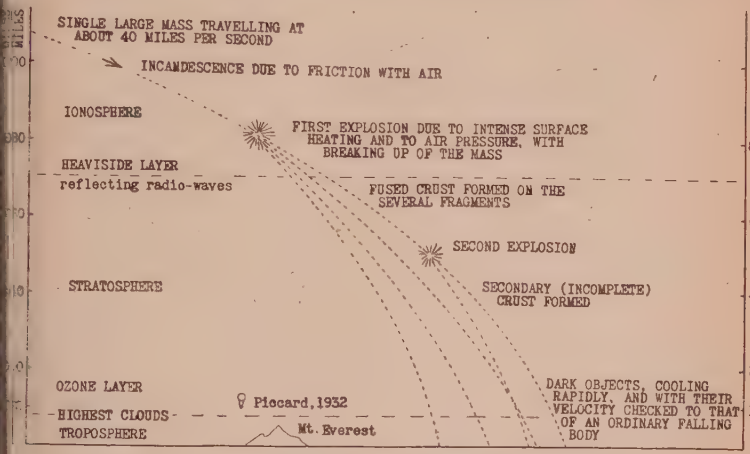


FIG. 4. Diagram of the fall of a shower of meteorites.
Owing to air resistance and the force of gravity, the smaller stones fall first and the larger ones carry farther.

wer temperature was developed. A stone of the Beardsley (Kansas, 1929) shower in the British Museum collection shows four stages the crust, indicating that there were three explosions during the ght of the meteorite through the earth's atmosphere.[1]

Air resistance has operated to such an extent that with ordinary eteorites their initial velocity has been almost completely eliminated, e energy of motion being transformed into heat. Heat is then no nger generated, and for the last few miles the stones fall under the fluence of gravity with a maximum velocity of an ordinary falling dy—about 70 metres per second, but depending on the size and nsity of the body. The surface is quickly cooled, and the last-rmed molten material consolidates as a thin layer of glass, forming e well-known crust. The air resistance is proportional to the square the radius of the body, while the mass and its momentum are

[1] Min. Abstr., 1933, vol. 5, p. 300.

proportional to the cube of the radius. Smaller masses will therefor be relatively more checked than larger masses. In a shower th smaller masses will reach the ground first and in a more nearl vertical direction, while the larger masses will carry farther and i a direction more inclined to the vertical. This is illustrated dia grammatically in text-fig. 4.

Unfortunately, in the case of the Tenham shower which, accordin to B. Dunstan, extended over 41 miles of ground in the direction c flight (text-fig. 1), there is no record of the distribution of the stone This range of 41 miles is considerably greater than is usually the case but it is not beyond doubt, for M. Hammond (1936) gives the lengt of the track as 12 miles. The tracks of showers that have been pre viously listed are only 3 to 16 miles long;[1] but these have no included the Futtehpur (India, fell 1822) shower, which ranged fc some 70 miles.[2]

It has sometimes been suggested that craters supposed to b meteorite craters, but associated with which no meteoritic materia has been found, might have been formed by the fall of a large mas of meteoric stone, which would itself be broken into fragments an pulverized, to be soon afterwards decomposed by weathering. Suc a suggestion has been made in the case of the famous Siberian fall c June 30, 1908, where no meteoritic material has yet been detected But it is evident that any such large meteoric stone would hav already been broken up in the earth's atmosphere and its energ distributed and dissipated in a shower of smaller masses. With a larg mass of iron the matter is different. This is not so easily broken u in the atmosphere, and with a really large mass the effect of the cub of the radius will predominate over the effect of the square of th radius, with the result that the mass may arrive at the surface c the ground with cosmic velocity. The kinetic energy is suddenl transformed into heat with the production of a very high temperatur sufficient to vaporize some of the meteorite and the terrestrial rocks giving rise to a violent gaseous explosion and so forming a crater an shattering and scattering the remnants of the meteorite.

[1] L. Fletcher, Min. Mag., 1889, vol. 8, p. 226; O. C. Farrington, Meteorite 1915, p. 46.

[2] C. A. Silberrad, Min. Mag., 1932, vol. 23, p. 299.

[3] L. J. Spencer, Min. Mag., 1933, vol. 23, p. 399; Meteorite craters as top graphical features on the earth's surface. Geogr. Journ., 1933, vol. 81, pp. 227 248; and Ann. Rep. Smithsonian Inst., 1935, for 1933, pp. 307–325.

Queensland Meteorites.

The following list of Queensland meteorites is based on the lists of . Anderson (1913), B. Dunstan (1913), H. C. Richards (1930), and . T. Prior's British Museum catalogue (1923 and 1927).

Gladstone, Port Curtis district. Siderite, 14½ cwt., found 1914, ur miles south of Gladstone. 23° 54′ S., 151° 18′ E. Queensland overnment Mining Journal, 1926, vol. 27, p. 312; H. C. Richards, em. Queensland Museum, 1930, vol. 10, p. 66, pl. 8 [Min. Abstr., 4-426].

Glenormiston, Gregory North district. Siderite, 85½ lb., found 1925,) miles west of Boulia. 22° 54′ S., 138° 43′ E. H. C. Richards, loc. it., p. 65 [M.A. **4**–426].

Mungindi, Maranoa district. Siderite, two masses, 62 and 51 lb., nd 1897, over the border, three miles NNE. of Mungindi, New uth Wales. 28° 58′ S., 149° 0′ E. G. W. Card, Rec. Geol. Surv. ew South Wales, 1897, vol. 5, p. 121.

Rockhampton, Port Curtis district. Three stones, one of about .5., fell in the town in the spring of 1895. 23° 23′ S., 150° 31′ E. Tryon, Queensland Naturalist, 1910, vol. 1, p. 170.

Tenham, Gregory South district. Shower of more than 104 stones, tal weight more than 113½ lb. (perhaps about 350 lb.), fell about bruary, 1879, near Tenham station (25° 44′ S., 142° 57′ E.), miles SE. of Windorah.

Thunda, Gregory South district. Siderite, 137 lb., found before 86 near Thunda (25° 30′ S., 143° 4′ E.), 30 miles E. by S. of ndorah. A. Liversidge, Journ. & Proc. Roy. Soc. New South ales, 1887, vol. 20 (for 1886), p. 73; 1889, vol. 22 (for 1888), 341.

According to M. Hammond (1936) two masses of iron, the 'Old n' and the 'Old Woman' were known to the aboriginals on Githa · Gether) Creek (text-fig. 1; 25° 42′ S., 143° 3′ E.) on the Maroo lding. One of these (the 'Old Woman') was shown to him in 31, and it was afterwards transported to the Thunda homestead, out 15 miles to the north.

Warbreccan, Mitchell district. Three stones, 69, 64, and 1 lb., said have been found in 1904 about 40 miles west of Windorah, i.e. at out 25° 25′ S., 142° E. in Gregory North district. These stones, wever, probably belong to the Tenham shower (p. 446).

The following require confirmation and description:

Cecil Plains, Darling Downs district. Listed by G. T. Prior (19
from G. W. Card's MS. list (1925).

Ellerslie, Maranoa district. Stone 22½ lb. Listed by G. T. Pr
(1927) from G. W. Card's MS. list (1925).

Le Gould, Leichhardt district. Like a cannon-ball, found nea
felled tree two days' march beyond the Isaacs river. It was
collected, and there is no evidence that it was a meteorite. Le Gou
Geol. Mag. London, 1864, vol. 1, p. 142.

Queensland. H. A. Ward (1904), omitted by O. C. Farring
(1916), and discredited by G. T. Prior (1927). Perhaps a fragm
of Thunda.

Explanation of Plates XIV–XVII.

Meteoric stones from the Tenham (Queensland) shower of 1879.
(Photographs of pls. xiv–xvi by the Department of Agriculture and Stock, B
bane; of pl. xvii by D. L. Williams, Mineral Department, British Muse
of Natural History.)

Plate XIV. Twelve stones, nos. T 1–T 12. × ¼.

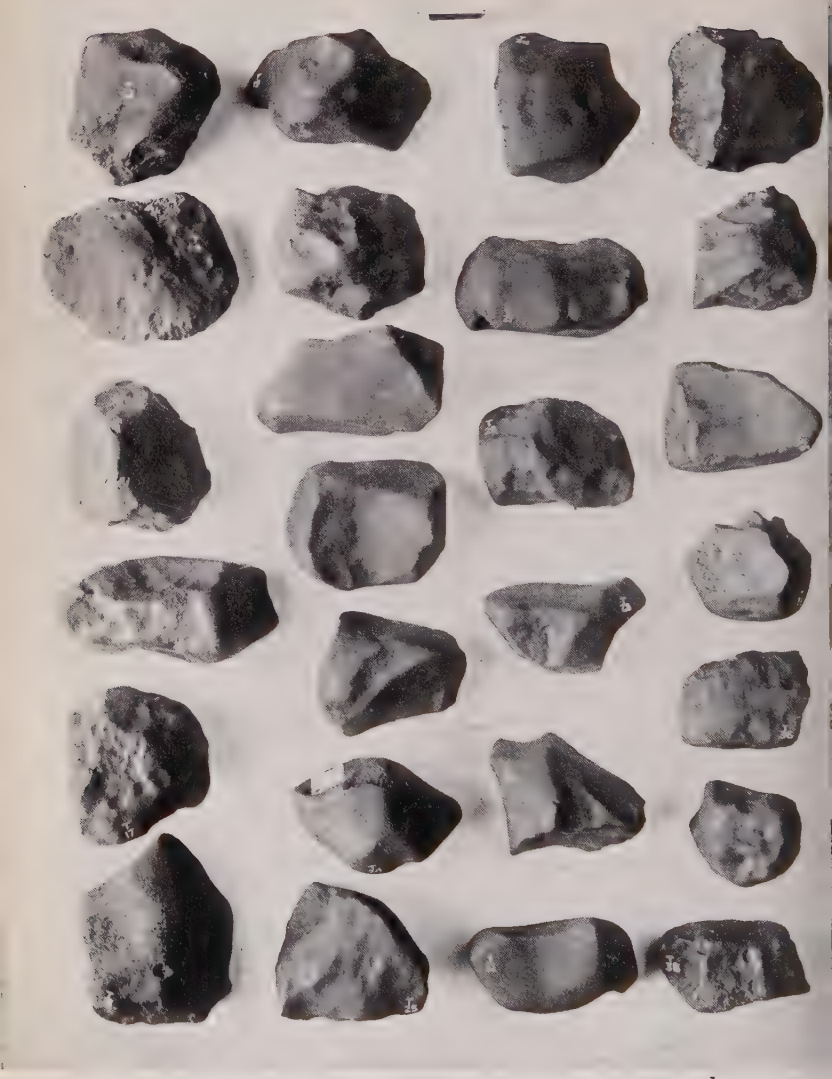
— XV. Twenty-six stones, nos. T 13–T 38. × ¼.

— XVI. Sixty-two stones, nos. T 39–T 100. × ¼. The scale at the to
pls. xv and xvi is three inches long.

— XVII. Fig. 1. Polished section of T 65, showing the stony portion w
chondrules. × 1¾.

— — Fig. 2. Same section with light reflected from the meta
portion. × 1¾.

L. J. SPENCER : TENHAM METEORITIC SHOWER
(Twelve stones, nos. T 1–T 12. $\times\frac{1}{4}$)



L. J. Spencer: Tenham meteoritic shower
(Twenty-six stones, nos. T 13–T 38. $\times\frac{1}{4}$)

L. J. Spencer : Tenham meteoritic shower
(Sixty-two stones, nos. T 39–T 100. $\times\frac{1}{4}$)

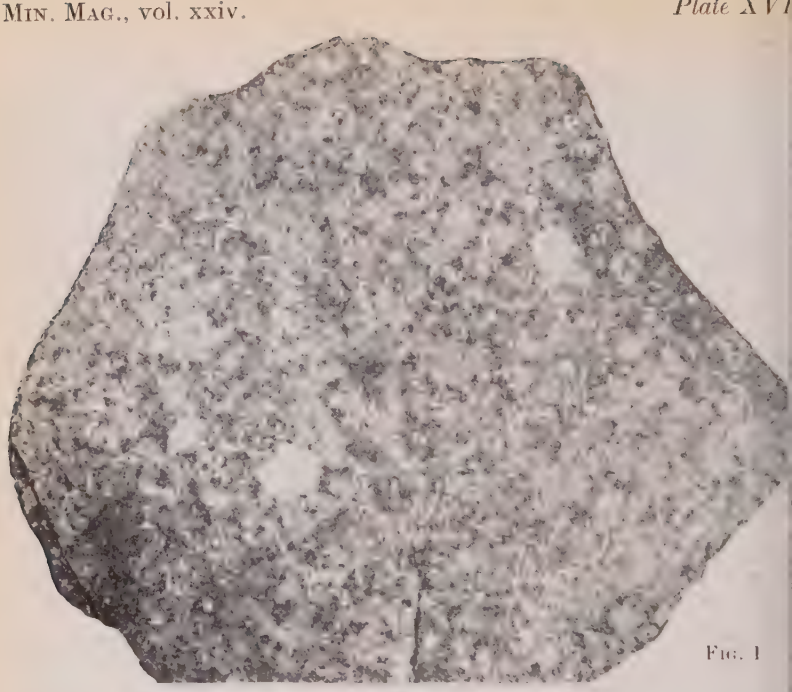


FIG. 1

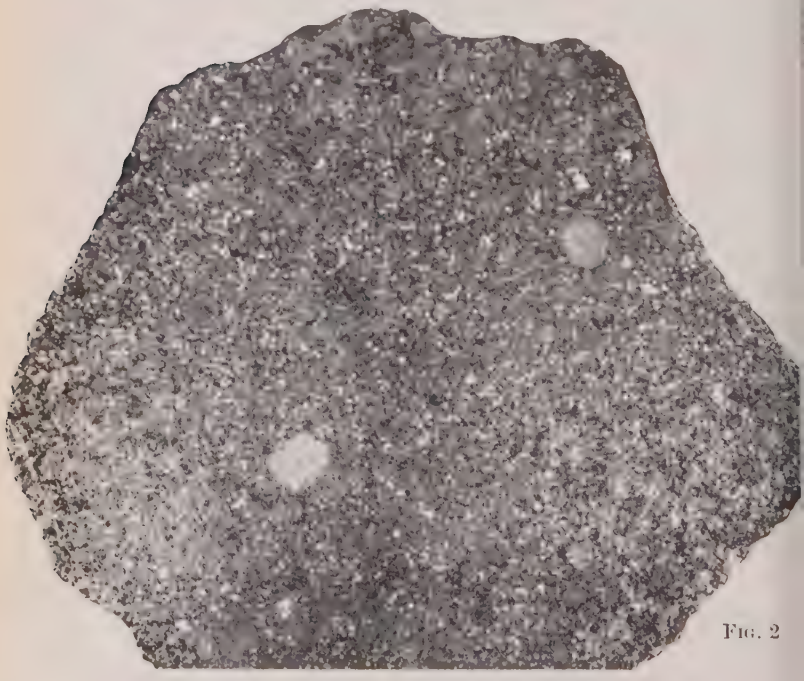


FIG. 2

L. J. SPENCER: TENHAM METEORITE

The potash-soda-felspars. I. Thermal stability.

(With Plate XVIII.)

By Edmondson Spencer, A.R.S.M., D.Sc., F.I.C.

[Read January 28, 1937.]

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I. Introduction.

IN a previous paper (24)[1] the writer discussed the relations betwe the chemical and physical properties of a number of potash-sod felspars, mainly of the schillerized or perthitic variety, and the effe of high temperatures upon them. The present paper gives the resul of further examination of these and of several additional specime selected to make the range of composition more complete.

Twenty-six specimens were selected for this investigation. Th include two albites, six microclines, and eighteen felspars which ha been grouped as an orthoclase-microperthite series. The confus nomenclature of the alkali-felspars makes a choice of suitable nam difficult. Alling's classification (1, pp. 253–254) represents a system tic attempt to overcome this confusion, but it seems doubtful wheth some of his arbitrary subdivisions (e.g. 'anorthoclase potential eutectoperthite' and 'microcline eutectoperthite') can exist. T expression 'orthoclase-microperthite series' is used throughout th paper in a strictly limited sense for a continuous series betwe potash-rich, non-perthitic orthoclase felspar, and the higher-soc schillerized type with more or less complete exsolution of the soc component. It is not certain that this series continues unbroken albite, but it extends to specimens with about 60 % soda-felspa The series includes a number of specimens (J to R, tables I and which normally—and by Alling's classification—would be call anorthoclase, but it does not include the glassy, non-perthitic sa dines or anorthoclases of the Haddington, Mt. Kenya, Panteller and Mt. Erebus types, which will be discussed separately. Althou the microclines show perthitic structure, they do not belong to th series, nor is it certain that adularia does. The Eifel sanidine a Korea moonstone (specimens G and P) do not strictly belong to t series; they are included to show how, by heat treatment, t properties of the orthoclase-microperthite series may be changed those of the sanidine-anorthoclase series.

Most members of this orthoclase-microperthite series show a bl or white schiller and a very fine perthitic structure. The perth belongs in part to Andersen's 'film' or 'string' type (3, p. 149) a in part to Brøgger's 'cryptoperthite' (8, pp. 524–551).

[1] Numbers in parentheses refer to the table of literature on p. 493.

[2] Unless otherwise stated, compositions are expressed in weight, and not molecular, percentages.

The six pegmatitic microclines also show this 'film' or 'string' perthite, but on a somewhat coarser scale. In one or two of them a still coarser form occurs in association with the 'film' perthite. While it can scarcely be classed as 'film' perthite, it is too fine and regular to belong to Andersen's 'vein' perthite.

Most microclines are too heterogeneous or opaque for accurate optical determination. The six specimens (U to Z) were chosen because of their relative clearness. Their compositions fall within a rather limited range; it is certain that more extreme compositions and physical properties could have been found in the rejected material.

II. Chemical Composition.

The analyses of all specimens examined are set out in table I (p. xviii) in three groups in order of increasing soda-content. Specimens marked with an asterisk have been previously described; one or two minor corrections, obtained from recent repetitions, have been introduced into their analyses.

It will be seen that all the specimens are relatively poor in lime. The three (O, Q, and R) with the highest lime-content contain minute inclusions of apatite or tourmaline. In the table all the lime present has been calculated as anorthite. Specimens B and G contain appreciable amounts of barium.

In the orthoclase-microperthite series, the soda-felspar content ranges from about 4 % to 52 %, increasing by fairly uniform steps. In the microcline series the soda-felspar ranges between the narrow limits of 13 % and 22 %. The maximum range for all the microclines examined by me was about 8 % to 31 %; as noted above, many of these felspars were unsuited for optical measurement. Vogt (3, pp. 29–40) and Andersen (3, pp. 166–167) have also observed a similar limited range of composition.

Notes on table I.—Specimens A, C, D, F, H, L, O, Q, and S have already been described (24).

A. Large crystal, about three inches in diameter, with outermost one-eighth of skin containing vermicular chlorite. Only clear uniform inner parts were used. St. Gothard, Switzerland.

B. Tabular phenocrysts in garnetiferous granite-gneiss. Railway-cutting near Jeypadowla, Kalahandi State, Orissa, India.

C. Probably from a basaltic tuff. Eifel, Rhineland.

D and J. Moonstone from Ambalangoda, Ceylon.

E. From the contact of a pegmatite with limestone. Myo Taung, 3¼ miles south-east of Mogok, Burma.

M. Moonstone from Ambalangoda, Ceylon.

N. With white schiller and fairly coarse microperthite. Oksaung Dau 3¼ miles east-north-east of Mogok, Burma.

P. Small, glass-clear, idiomorphic crystals, twinned on Carlsbad, Baveno, Manebach laws. Kanchin-do, Meisen-gun, north-east Korea.

R. With deep blue schiller. Contains minute inclusions of tourmaline apatite. (001) sections show under the microscope a 'lattice' pattern, of sort figured by Alling as 'incipient microcline-twinning' (1, p. 273 and pl. The 'lattice' directions correspond, however, to prism traces, and not to traces of (100) and (010). Fredriksvärn, Norway.

T. A glass-clear specimen of albite. Portions of the crystal show regula arranged microscopic solution-cavities that suggest a hydrothermal origin. Fr the mica-pegmatites of Kodarma, Bihar, India.

U, V, and Z. These three specimens come from the mica-bearing pegmatite Kodarma, Bihar, India. The first two are almost glass-clear, the third somew opaque in thick section. All show medium coarse microperthitic structure the 'string' or 'film' types.

W and X. From the graphite-bearing pegmatites of Patna State, Orissa, In These pegmatites border the granite-gneiss intrusions of the Kalahandi area, may belong to the same period of igneous activity. Both specimens show fa coarse regular microperthite.

Y. From a quartz-felspar-tourmaline-pegmatite near Ryagada gorge, Ori India. The specimen shows two generations of microperthite, one of the 'film' or 'string' type, and one distinctly coarser, but just as uniform as first. The microcline is semi-transparent in fairly thin flakes.

III. Physical Properties.

The refractive indices, optic axial angles, extinction-angles, specific gravities of the specimens examined are set out in table (pl. xviii). The specific gravities were measured by the met previously described (24, p. 352). Optic axial angles were measu on the microscope with a stage goniometer, the crystal plate be immersed in a liquid matching its mean refractive index.

Refractive indices were determined on small specimens wh polished faces were cut parallel to the principal planes of indicatrix. This preparation was facilitated for many of the pota soda-felspars by the fact that the cleavage-plane (010) is paralle one of the planes of the indicatrix. An Abbe oil refractometer used, and was checked from time to time against known standar

IV. Relations between Composition and Physical Properti

(*a*) *The orthoclase-microperthite series.*

The data given in tables I and II (pl. xviii) show that, with a exceptions, a regular progressive relationship exists between

fractive indices, optic axial angle, extinction-angle, specific gravity, nd composition in the orthoclase-microperthite series. The relation tween the last three properties and composition has already been scribed (24, pp. 340–345) for some members of the series.

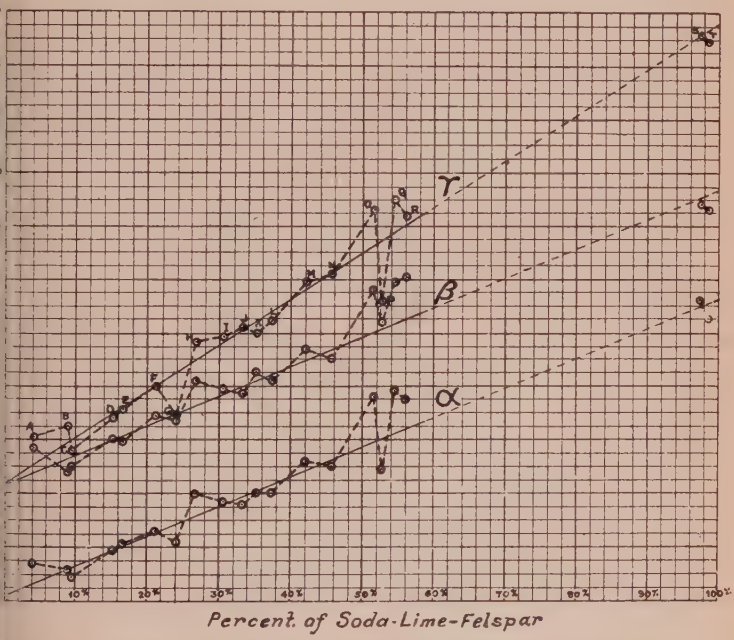


FIG. 1. Refractive indices and chemical composition of the orthoclase-microperthite series.

efractive index.—In general the mean values of α, β, and γ rease with increase in the soda-lime content of the felspar; $\beta - \alpha$ ains sensibly constant throughout. The smoothed curves of fig. 1, n produced, pass close to the plotted indices of albite, showing that refractive indices of the two felspar components are additive. It be seen later that this holds only when the exsolution of the a-component is complete. The points for A, H, O, Q, and R lie ve the mean lines; for any one specimen the deviation is approxi-ely the same for all three indices. These deviations are explained the chemical 'impurities'; H, O, Q, and R contain minute usions of highly refracting minerals (probably apatite or tourma-), while A is comparatively rich in ferric iron. Specimens G and anidine) have refractive indices below the mean, with different

deviations for each index. Adularia (specimen B) has γ above a β below the respective means.

Optic axial angle.—The upper curve of fig. 2 connects the op axial angle with composition; the points representing untrea specimens are enclosed in circles. The prolongation of the nea

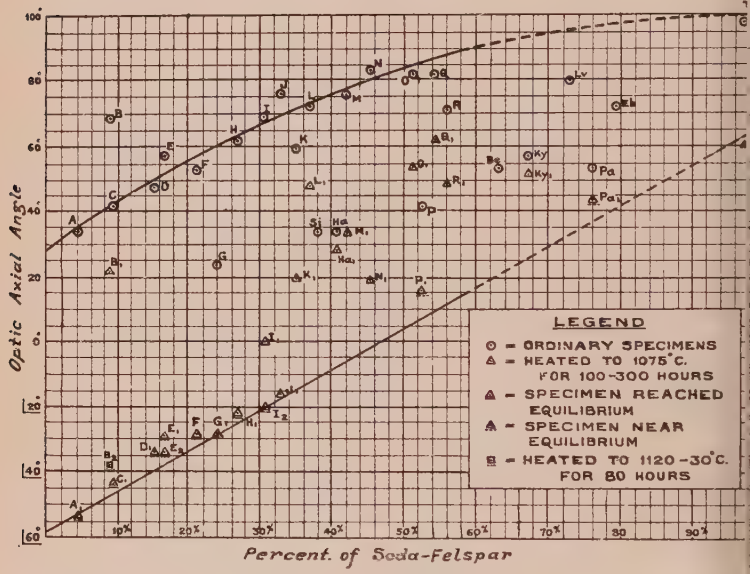

Optic Axial Angle
Percent. of Soda-Felspar
LEGEND
= ORDINARY SPECIMENS
= HEATED TO 1075°C. FOR 100-300 HOURS
= SPECIMEN REACHED EQUILIBRIUM
= SPECIMEN NEAR EQUILIBRIUM
= HEATED TO 1120-30°C. FOR 80 HOURS

FIG. 2. Optic axial angle and chemical composition: ordinary and after prolonged heating.

linear curve again lies close to the points for albite. As might expected, the impurities which caused uniform deviations of refractive indices of A, H, O, and Q do not greatly affect the op axial angles. The specimens of adularia (B) and sanidine (G and do not conform to the curve, while K and R show rather low valu

Specific gravity and extinction-angle on (010).—Fig. 3 shows variations of specific gravity and extinction-angle with compositi in both of which a general increase with increasing soda-content seen. Deviations from the mean specific gravity curve on the wh resemble those for the refractive index, and have a similar expla tion. The deviations of extinction-angle are of the same type those for the optic axial angle, and, as will be seen, are caused by special conditions under which the felspars have formed.

In summary, these results for the orthoclase-microperthite series confirm the relationships brought out in the previous paper (24), and extend them to include the three refractive indices. Two kinds of deviation were again found, namely, (*a*) those caused by the presence of impurities, which only affect refractive indices and specific

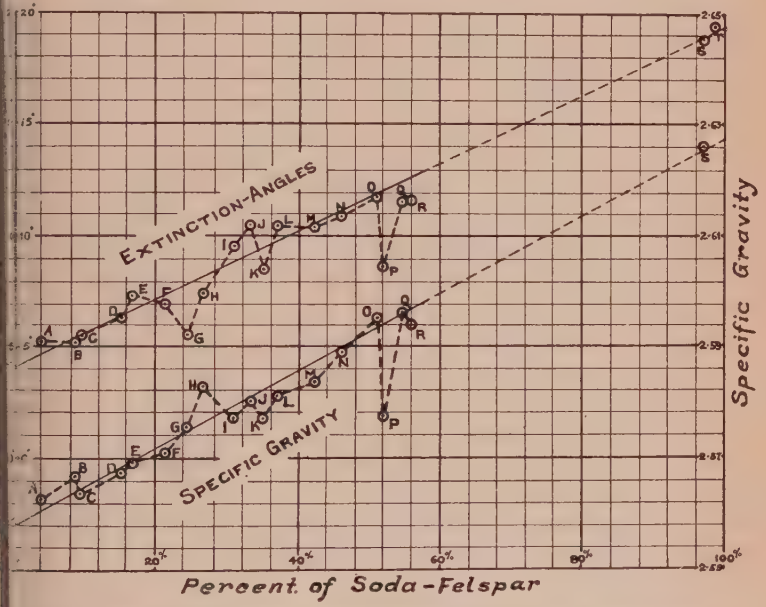


FIG. 3. Extinction-angles, specific gravity, and chemical composition.

gravity; (*b*) those caused by incomplete exsolution, which affect all the physical properties, but the optic axial angle more than the rest.

The same relationship has been found to hold for many more specimens than could be included in this selected list. In one or two instances where a slight discrepancy was found that could not be accounted for by the factors mentioned, a re-examination proved that either the analysis or the physical determination was at fault. For these reasons the writer would now question any results for potash-felspars that did not conform fairly closely to these relationships, allowing for the types of deviation mentioned above.

While the refractive indices, specific gravities, optic axial angles, and extinction-angles on (010) thus vary proportionately with the

amounts of potash- and soda-felspar present, the same is not true the extinction on (001), and the inclination of the β-axis of t indicatrix to the crystallographic axis-*b*. For albite the extincti on (001) is about 4–5°, and the inclination of the β-axis to the *b*-ax is about 15°. In orthoclase they are both zero, and remain zero nearly so in the orthoclase-microperthite series up to 40–50 % soda-component, whether the albite is present as perthite or not. a few cases the extinction on (001) is 1–3°, the β-axis of the indic trix still remaining nearly normal to (010)

(*b*) *Albite.*

The refractive indices, specific gravities, and optic axial angles, & of the two albites call for no special comment. They fall approx mately on the extension of the curves for the orthoclase-microperthi series, indicating that exsolution in the perthitic members of th series is fairly complete.

(*c*) *Microcline series.*

The refractive indices and optic axial angles of the microclin when plotted against composition, show a considerable deviati from those of the orthoclase-microperthite series, and, in order avoid confusion, they have been plotted separately on fig. 4, p. 46 with the mean lines of the orthoclase-microperthite series added f comparison. The values for adularia have also been introduced show how the refractive indices and optic axial angle of this felsp are closer to microcline than to the orthoclase-microperthite seri This similarity is better seen in the heat-treatment experiments.

As indicated on p. 455, these six microclines, chosen for the transparency and homogeneity, may not be truly representative average microcline-felspar. Although their optic axial angles a distinctly larger than those of corresponding orthoclase-microperthit they are smaller than the axial angles of most microclines. In t latter, which usually show coarser perthite and coarser multiple-tw structures, the axial angle rarely falls below 2V 80° and may be high as 85–87°.

V. Heat-treatment.

Larsen (18, p. 89) suggested that a knowledge of the crystalliz tion temperatures of rock-magmas might be obtained from the co sideration of the unmixing temperature of the microperthite felspa In view of this possible use of the microperthite transformation

'geological thermometer', it is surprising that so few attempts have been made to determine the temperatures at which these structures go into, and out of, solid solution.

Dittler and Köhler (11) observed the progressive microscopic changes produced in perthitic microcline on heat-treatment. They

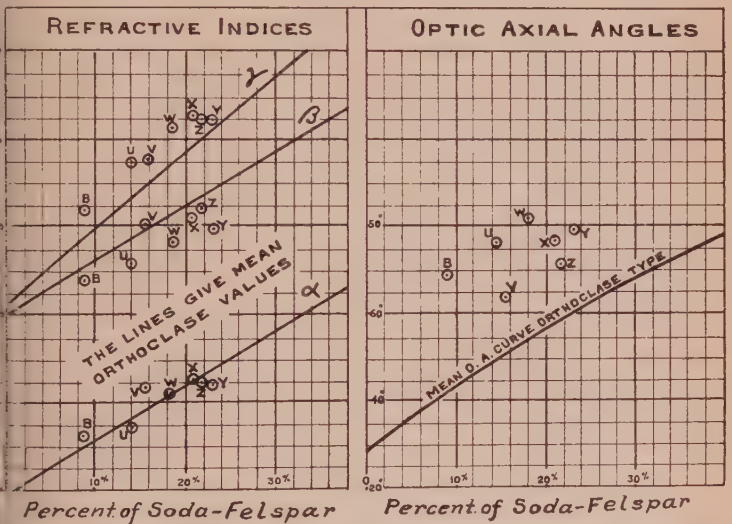


Fig. 4. Refractive indices, optical axial angle, and chemical composition of microclines.

and that the fine microperthitic lamellae could be dissolved by prolonged heating at 900° C., but that the coarser 'vein' type of perthite required a longer time at a higher temperature for its solution. The chief disadvantage of the microscopic method lies in the difficulty in judging the beginning, the end, or the amount of progressive change.

Kôzu and Endô (13) took Laue photographs of Ceylon and Korean moonstone, both said to be free from microperthitic lamellae. The pattern, which in the unheated material was double, became single after the specimens had been heated to 700° C. and 1000° C. respectively. On slow cooling down to 700° C., the Laue pattern of the Ceylon moonstone became double once more; no further change took place below 700° C.

The writer (24) showed that the destruction of schiller in Ceylon moonstone was accompanied by a solution of microperthite and

a reduction in specific gravity. The drop in specific gravity w proportional to the amount of perthite dissolved, up to about 40 of soda-component. For the majority of the felspars most of t change took place between 450° C. and 750° C., and was complet in a few minutes. Very little additional effect was noted on lo continued heating at any given temperature.

Barth (5) recently carried out long-period heating tests on number of potash-soda-felspars, including some perthitic typ mainly with a view to observing changes in optic axial angle a extinction. His results show that these felspars suffer no change extinction-angle on prolonged heating at 1000° C. In felspars w less than 25 % soda-component the optic axial angle is reduced.

Criticizing Dittler and Köhler's results for microperthitic felspa Barth says (5, p. 58), ' Determinations of inversions or any change physical properties of such homogenized perthites have therefore l little significance; they are, at best, only measures of rate diffusion '. This statement implies that perthitic solution on heat is a relatively slow process, which, if true, would of course make difficult to ascertain the temperature of solution accurately. It a suggests that changes brought about during or subsequent to he treatment are slight and unimportant.

In the following pages the writer shows that solution of perth in the orthoclase-microperthite series—and to a lesser extent in microperthitic microclines—is a relatively rapid phenomenon, that the temperature range of solution is determinable by measur the accompanying changes in refractive index and specific gravity

As will be seen later, natural rock cooling conditions must h been far too slow to have retarded the exsolution of perthite ordinary potash-felspars with high optic axial angles. Hence felspars of this type occurring in nature with more than about 1 of soda-component must have some soda-felspar present as mi perthite. By heat-treatment this microperthite can be redissolv usually with little effect upon the optic axial angle. These ho genized high-angle microperthites—not the homogeneous low-ar sanidine and anorthoclase—are the true soda-rich representatives the naturally homogeneous soda-poor orthoclase. Although sanidines have attracted most attention because of their susce bility to change on heating, it is equally necessary to examine effects of high temperature upon the properties of the homogeni microperthites.

Lack of discrimination in the behaviour toward heat-treatment the fine 'film' or 'string' types of perthite of exsolution origin nd the coarser 'vein' perthite has led to much confusion in estimates the rate of homogenization. Dittler and Köhler (11, pp. 257–8), owever, emphasized that the fine perthite can be taken into solution uch more readily than can the 'vein' type. All the perthites that ve been used for the tests now to be described belong to the adily soluble micro- or crypto-perthitic types, and are undoubtedly exsolution origin.

The effects of heat upon these felspars vary with the temperature, e period of heating, the composition, and the type of felspar. To plify description the results have been arranged as follows:—

1. Heating for short periods at progressively higher temperatures to near the melting-point. The results for each group of speci-ns are considered for two divisions of the temperature range:

(*a*) up to 850° C.,

(*b*) from 850° C. up to near the melting-point.

2. Prolonged heating at 1075° C. The results for each group of pecimens are given separately, the orthoclase-microperthite series ng divided into:

(*a*) specimens with less than 30 % soda-felspar,

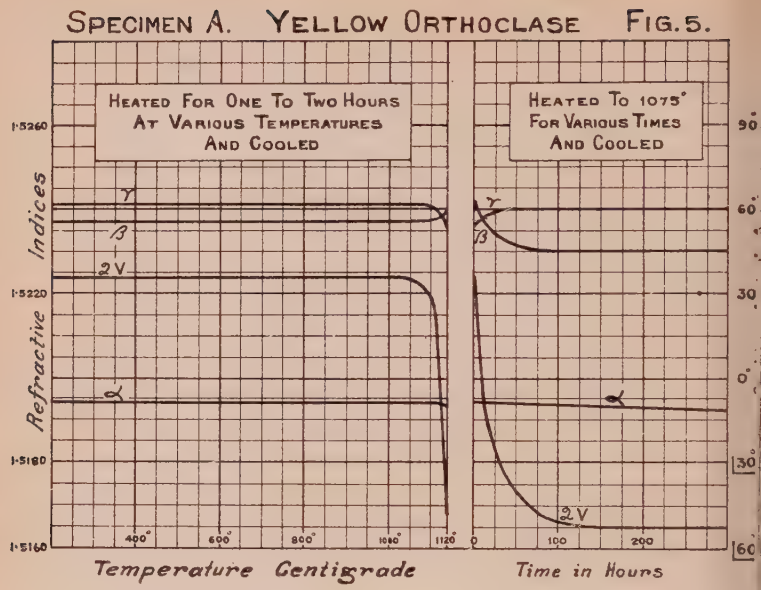
(*b*) specimens with more than 30 % soda-felspar.

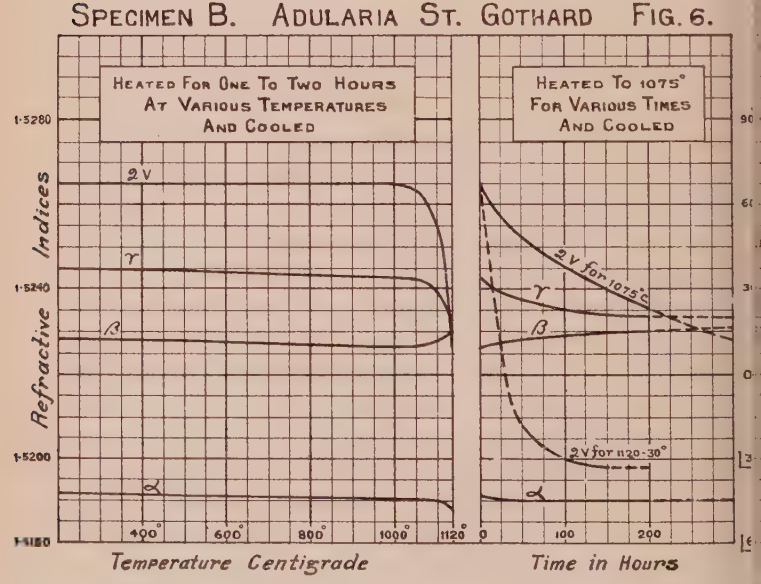
VI. Results of Progressive Heating to 850° C.

Specimens prepared for the determination of refractive index were ted in a small electric furnace, whose temperature was measured a Pt–Rh thermocouple and millivoltmeter. The period of heating s one hour, after which the specimens were rapidly cooled in air. ere rapid changes took place temperature intervals of 50° C. were d; elsewhere the interval was 100° C. Curves were drawn for h specimen to show the refractive indices and optic axial angle ll temperatures to near the melting-points. Twelve of the most resentative of these are shown in figs. 5–16, while the results are fly summarized below.

(*a*) *Orthoclase-microperthite series.*

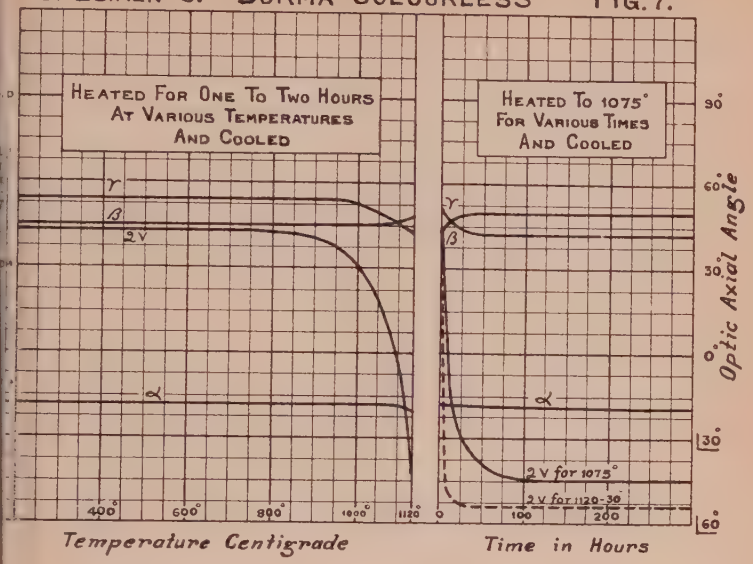
eduction of refractive index and specific gravity.—A decrease in active index is found on heating all the schillerized perthitic pars (specimens D to R) to 850° C. Except in one or two cases



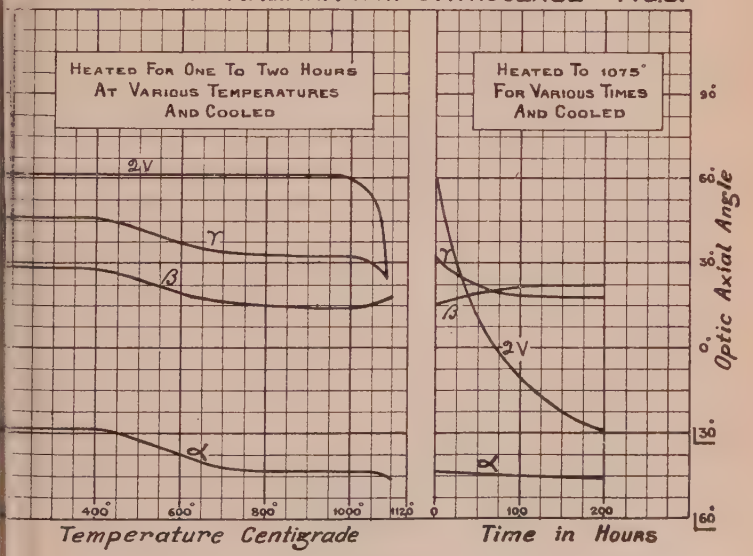


Changes in the optical properties on heating.

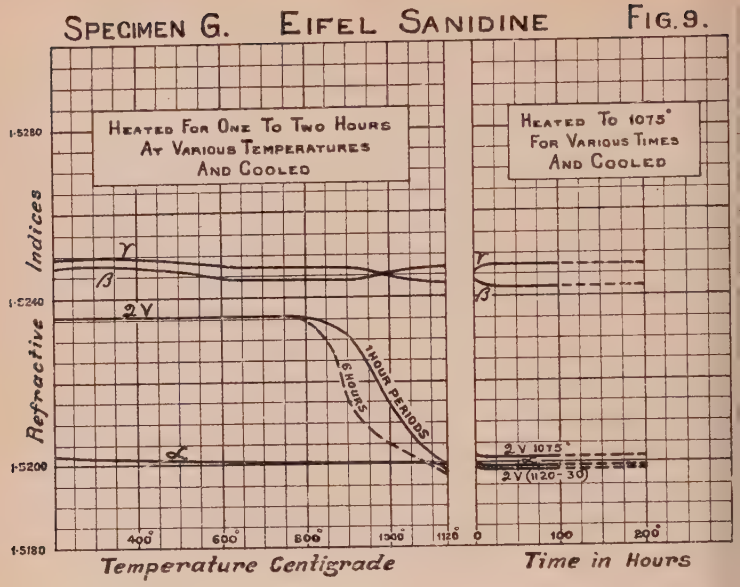
SPECIMEN C. BURMA COLOURLESS FIG. 7.

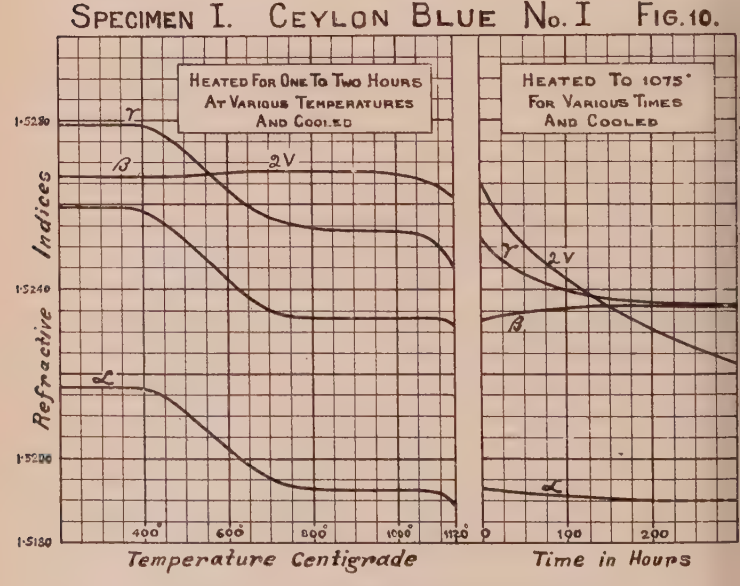


SPECIMEN E. KALAHANDHI ORTHOCLASE FIG. 8.

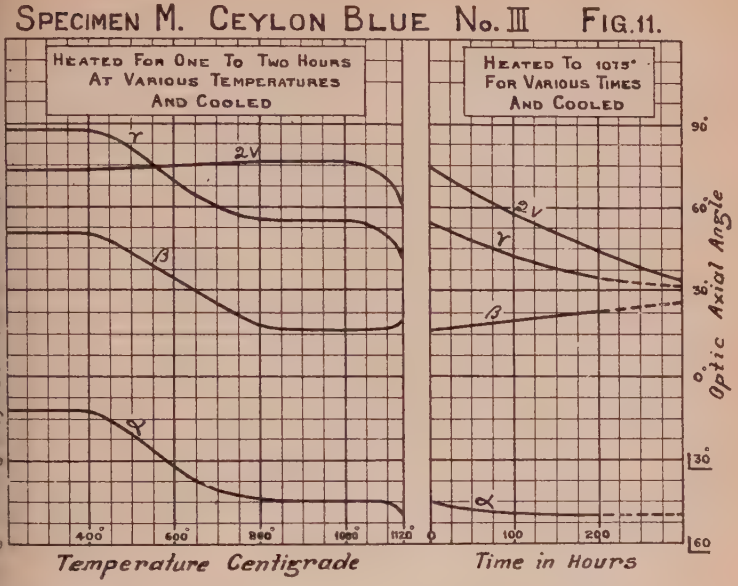


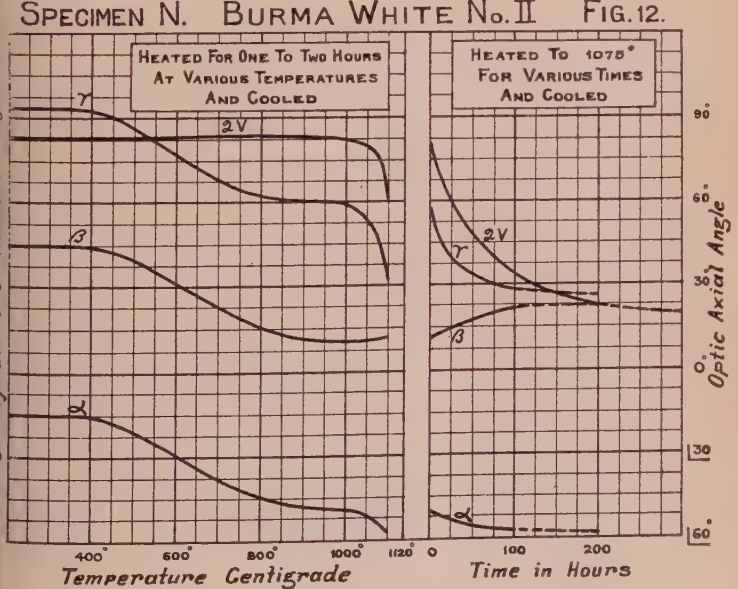
Changes in the optical properties on heating.



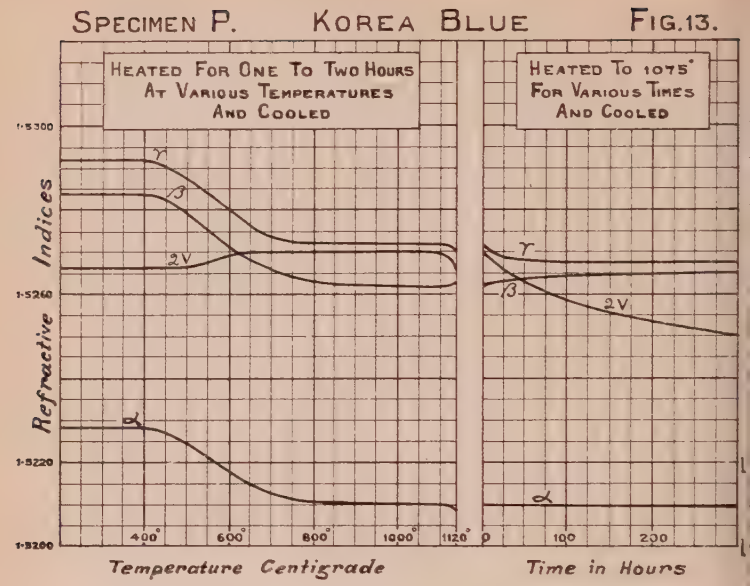


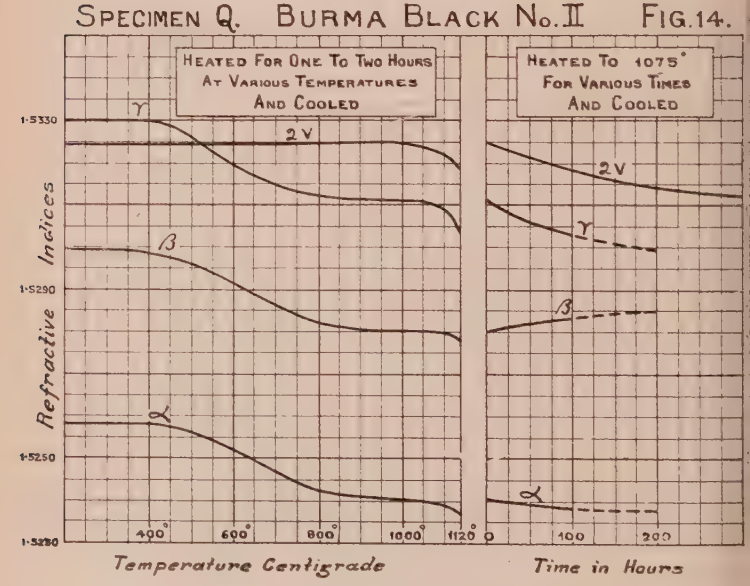
Changes in the optical properties on heating.





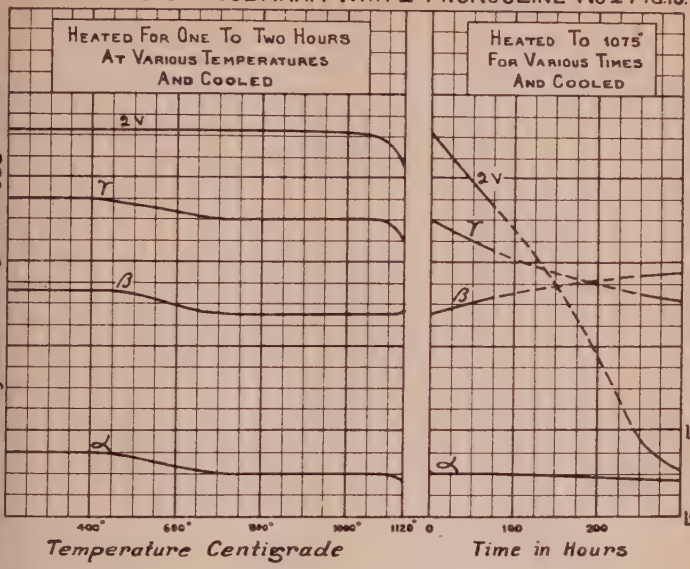
Changes in the optical properties on heating.



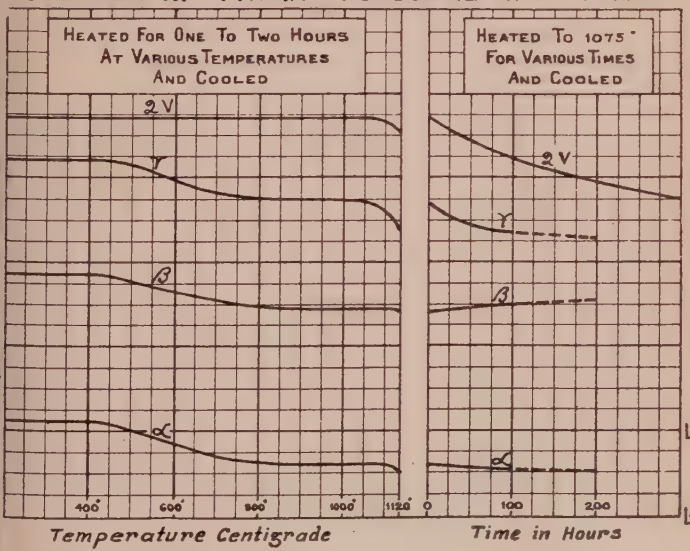


Changes in the optical properties on heating.

SPECIMEN U. KODARMA WHITE MICROCLINE No I FIG.15.



SPECIMEN W. PATNA MICROCLINE No. I FIG. 16.



Changes in the optical properties on heating.

where a change in optic axial angle takes place, the decrease is t
same for each of the three indices (see figs. 5–14). The soda-po
non-schillerized specimens A, B, and C show no such decrease
heating, and the non-schillerized sanidine G, although richer
soda, shows only a slight effect. The changes begin between 350°
and 450° C., and are completed between 650° C. and 850° C.:
temperature of beginning and end of the alteration is higher in
varieties richer in soda.

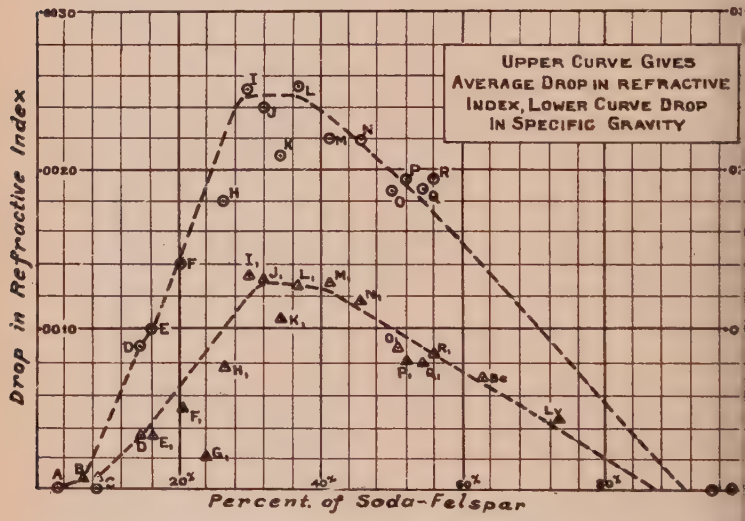


FIG. 17. Drop in refractive indices and specific gravity after rapid cooli
from 850° C.

The drop in each of the refractive indices on heating to 85
increases nearly linearly with the soda-felspar content between al
8 % and 30 %,[1] while between 30 % and about 50 % the dro
proportionately less. These relations are exhibited in the u
curve of fig. 17. Since albite shows no decrease in refractive ir
after this heat-treatment, the curve is prolonged tentatively tow
its plotted indices.

[1] A few specimens within this compositional range show a drop of refra
index and specific gravity less than their composition would suggest. The
have a white schiller and rather coarse microperthitic structure, which are
difficult to destroy by heating than those of the normal moonstones. The pert
boundaries are sharper, perhaps owing to the presence of films of air or
mineral, which may be responsible for the greater resistance to perthitic solu

From these results it may be concluded that a maximum of about 0 % of soda-felspar may be taken into solution in orthoclase at 00°–850° C. A departure either way from this proportion permits ss soda-felspar to be taken into solution, and the accompanying op in refractive index is reduced. Soda-felspar in excess of 30 % ay be dissolved slowly by long heating above 850° C. with only slight further reduction in refractive index, and usually with some crease in optic axial angle.

It has already been shown (24, pp. 348–358) for many of these ecimens that there is a reduction of specific gravity on heating to 0° C., proportional to the soda-felspar content between 10 % and %. The soda-rich specimens now available show that this re-ction falls off when the soda-felspar exceeds 40 %, closely parallel- the changes in refractive index. The lower curve of fig. 17 ustrates this.

Changes in optic axial angle and extinction-angle.—A few specimens of orthoclase-microperthite series show a slight permanent increase the optic axial angle after heating to 850° C. The increase takes ce with the fall in refractive indices and the re-solution of the thite. The phenomenon is displayed by the blue schillerized croperthite types with 30 % or more soda-component, which have normal optic axial angles at ordinary temperatures. The increase larger the greater the deviation from the normal figure (see . 10–14).

Thus the optic axial angle of specimen R (2V 71·5°) is about 10° ow the normal and increases 2–3° on heating to 850° C. Several cimens from Ceylon and Burma with optic axial angles 2–6° below normal showed a rise of 1–2·5°. Specimen P (Korea), pheno-sts in a liparite probably from the same locality,[1] and felspars m the Sparling Gulch rhyolite previously described (24, p. 337) e optic axial angles before heating of 2V 38–40°. A rise of 4–6° es place on heating to 800° C.

Kôzu and Suzuki showed that the optic axial angle of moonstones n Korea and Ceylon rose 6° and 2° respectively on heating to –900° C.

[1] A brick-red, crumbly liparite probably from Kanchin-do, Meisen-gun, N.E. ea, contains blue moonstone phenocrysts up to one-eighth inch in diameter, ly resembling those from the rhyolite of Sparling Gulch, Colorado, in com-tion and physical properties. SiO_2 66·00, Al_2O_3 19·18, Fe_2O_3 0·88, CaO trace, 0·10, K_2O 7·76, Na_2O 6·06, loss 0·54, total 100·52. Composition $Or_{45·86}$ ·23. The low summation is caused by the presence of alteration-products.

The changes in extinction-angle on (010), already described Ceylon moonstone (24, p. 346), have been found to apply to all medium and soda-rich perthitic felspars with normal optic a angles. The greater part of the change, however, takes place on prolonged heating above 850° C., and is associated with further solution of perthite and reduction of optic axial angl these higher temperatures.

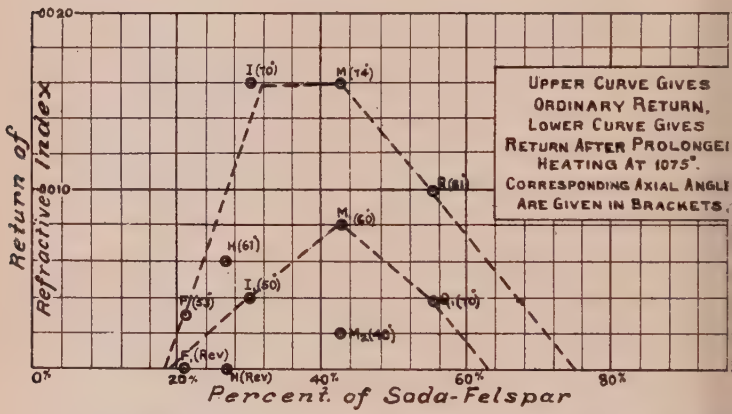


Fig. 18. Refractive indices changes: partial return on slow cooling from 850° C. to 350° C. over 20 days.

(*b*) *Partial return of the schiller, refractive index, and specific gra on very slow cooling.*

It has been found that much of the drop in refractive index, ca by heating to 850° C., can be restored by slow cooling in the furn Cooling from 850° to 350° C. over 100 hours reduced the refra index drop of specimens I and M from 0·0025 to 0·0015 and 0·0024 to 0·0014. Cooling for 500 hours over the same tempera range reduced the drop to about 0·0010 and 0·0009 respectively. a given rate of cooling the amount of return of refractive ind nearly proportional to the original drop on heating to 850° C. is shown for various members of the orthoclase-microperthite s in the upper curve of fig. 18.

The decrease in specific gravity shows a restoration on slow co similar to that of the refractive index: the results are set out in lower curve of fig. 18.

The schiller, which vanishes on heating, can be restored by

ooling. Flakes of specimens I and M, cut to show the maximum hiller, were heated for some hours at 1075° C., when the schiller as completely destroyed. Cooling for 500 hours from 800° to 0° C. caused a return of a strong blue schiller and visible micro-rthitic structures.

(c) *Significance of results.*

The results of these experiments prove that microperthite can be ssolved and re-precipitated from solid solution much more readily an has generally been supposed possible. Most of the solution kes place between the relatively low temperatures of 350° C. and 0° C., and so readily that the rate of cooling of quickly chilled as would not prevent complete exsolution, if the rapid cooling ected only that temperature range. The existence of such clear, n-schillerized soda-bearing felspars as Eifel sanidine cannot be due rapid cooling through that temperature region.

The results extend the first published experimental evidence of solution given by Kôzu and Endô (13), who probably obtained limited amount of exsolution in the upper temperature region, t who failed (owing to too rapid cooling) to show exsolution low 700° C.

VII. Results of progressive heating to 1120° C.

(a) *Changes in the orthoclase-microperthite series.*

Most members of the orthoclase-microperthite series with less an 30 % of soda-felspar show little further change on heating to 20° C. In general the resistance to change of optic axial angle creases with the soda-felspar content. The optic axial angle of ecimen C begins to decrease at 900–950° C., and becomes zero at out 1050° C. At 1100° C. the angle is nearly 30°, with the optic al plane parallel to (010). At the same time there is a corre-nding change in the indices γ and β.

Specimen A (yellow orthoclase, Madagascar), with a smaller soda-par content than specimen C, shows a greater resistance to change. s is probably due to the replacement by ferric iron of some of aluminium in the atomic framework. The first change begins about 1060–1070° C. (fig. 5, p. 464); above this temperature the nge is rapid. The optic axial angle is about 35° in the symmetry-

plane[1] after 10 hours at 1120° C. These results are similar to th found by Kôzu and Suzuki for this variety of orthoclase (16).

The change in specimen C resembles those found in Eifel sanid (specimen G), in which the optic axial angle becomes zero at 9 1000° C., and opens out again to about 28° in the symmetry-pl at 1100° C.

The changes in the optic axial angle of sanidine were first descri by Des Cloizeaux (9, 10). Kôzu and Suzuki (15) have recently fou that the first permanent change begins at about 900° C. Th obtained a value 2H 30° as the maximum optic axial angle in symmetry-plane after heating to 1100° C.

Adularia behaves anomalously in comparison with the other so poor members of the series (fig. 6, p. 464) and more closely resemb microcline than orthoclase. The temperature of the first change optic axial angle varies in different specimens from 900° C. to 1050 The change is erratic and sluggish even up to 1100° C. A b schillerized adularia, with the approximate composition[2]

$$Or_{84\cdot5}Ce_2Ab_{13}An_{0\cdot5},$$

was found to be equally resistant to change of optic axial an Although this specimen lost its schiller on heating to 850° C. (w slight drop in refractive index), the optic axial angle was o reduced from 2V 70° to 58° on six hours' heating to between 1120 and 1130° C. This anomalous behaviour of adularia is also sugges by the results of Kôzu's experiments (16, pp. 188–191) and is brou out more strikingly in the long-period heating tests described bel

(*b*) *Changes in albite.*

No appreciable change in refractive index or optic axial an could be seen in the two specimens of albite for hourly heatings u near the melting-point.

(*c*) *Changes in microcline.*

All six microclines showed a decrease in specific gravity and fractive index on heating to 850° C. For any specimen the sa decrease was found for all three refractive indices. The cha begins at about 400° C. and is finished at about 800° C. (see figs. and 16, p. 469). The drop is lowest for the specimens low in so

[1] Optic axial angles in the symmetry-plane are indicated in the diagrams a sign ⊥ placed against the values of the angles.

[2] SiO_2 63·88, Al_2O_3 19·58, Fe_2O_3 0·16, FeO n.d., CaO 0·10, MgO trace, BaO 0 K_2O 13·98, Na_2O 1·48, loss 0·20, total 100·09. From Zillerthal, Tirol.

felspar and increases with increase in soda. The decrease is less than that found for orthoclase-microperthites of corresponding composition. No further changes occur in these specimens on heating to 1000–1050° C. At the latter temperature some specimens show a slight, sluggish reduction in optic axial angle, more clearly seen in the long-period experiments.

VIII. Results of heating for long periods at 1075° C.

The temperature of 1075° C. was chosen for these prolonged experiments as being sufficiently below the melting-point to avoid the formation of glass, whilst being high enough to ensure fairly rapid transformation. N. L. Bowen (7) gives $1100° \pm 10°$ C. as the melting-point of albite, and Vogt, quoting Andersen (3, p. 87), states that mixtures of orthoclase with 40–70 % of soda-felspar begin to melt about 30° C. below the melting-point of pure albite. I have not been able to melt specimens with 30–50 % soda-felspar at 1100° C., but flakes or cut plates in contact tend to adhere on prolonged heating at temperatures as low as 1080–1090° C. Such flakes do not lose their crystalline properties, and little glass, if any, is formed. When, at higher temperatures, partial melting occurred, it was always found to begin at the surface or along cracks.

To avoid this adhesion, the specimens were loosely and separately packed in ignited precipitated silica. Albites and soda-rich specimens could be so heated for long periods at 1100–1110° C. without any loss of shape or crystalline structure. The electric furnace was automatically controlled and could be kept within 3° or 4° C. of any temperature up to 1200° C. The pyrometer was checked from time to time at the melting-point of pure copper (1083° C.), pure sodium chloride (794° C.), and pure zinc (420° C.). Specimens were heated for ten-hour periods for the first fifty hours, followed by periods of fifty hours. For most specimens, heating extended to 200–300 hours. As before, curves were drawn for each specimen examined, showing the change of optic axial angle and refractive index, but with time, instead of temperature, as abscissae. Figs. 5–16 (pp. 464–469) show twelve of these curves, and a summary of results is given below.

(a) *Changes in the orthoclase-microperthite series with up to 30 % soda-component.*

Changes of optic axial angle: the equilibrium angle.—With the exception of adularia, which strictly does not belong to the series, all

the orthoclase-microperthites, up to and including J (with 33 % soda-lime-felspar), were transformed to the abnormal or sanidine ty when heated for various periods up to 300 hours. Most of th specimens showed no further change of optic axial angle after first 100 hours' heating. The size of the optic axial angle in symmetry-plane decreases with increasing soda-content, while time taken to attain the final value increases as is shown below.

Specimen.	Optic axial angle 2V in (010) plane.	Time needed to attain equilibrium.
A	54°	90–100 hours
C	45	80–90
D	33	300
E	29	200
F	28	300
G	28	100
H	22	200
I	20	300
J	16	300

On reheating to still higher temperatures, these specimens g larger values for 2V. Specimens A, C, and G, on heating to 1120° for 12–14 hours, gave respectively 2V 58°, 53°, and 32°. Thus 'equilibrium angle' for these sanidinized felspars depends upon temperature as well as on the soda-content. The 'equilibrium angl for a temperature of 1075° C. are plotted in the lower part of fig (p. 458), and lie approximately upon a straight line.

Although the natural Eifel sanidine is comparatively rich in so it begins to change at a lower temperature than do the medium a soda-rich orthoclases. Its equilibrium angle for 1075° C. is less th those of the orthoclases A and C, and lies in true position on the lo curve of fig. 2. Two other specimens of sanidine from Eifel, of alm the same composition as specimen G, show optic axial angles normal temperatures of 2V 18° and 24° in the symmetry-plane, h after heating for 10 hours at 1120° C. both show angles of 2V 3 identical with specimen G.[1]

Changes in dispersion accompany changes in optic axial ang

[1] A sanidine from Mt. Cimino, Viterbo, Italy, now under examination, has approximate composition $Or_{81}Ab_{16}An_3$. It alters on heating more readily t does specimen G, beginning at 770° C. Heating for 10 hours at 1120° C. char the optic axial angle from 2V 13° in the symmetry-plane to 2V 34–35° in symmetry-plane. SiO_2 64·24, Al_2O_3 20·24, Fe_2O_3 0·22, FeO n.d., CaO 0·56, M trace, BaO n.d., K_2O 12·87, Na_2O 1·80, loss 0·50, total 100·43.

In those orthoclase-microperthites in which the optic plane is normal to (010) the dispersion is $r > v$, but when the optic axial plane becomes parallel to (010) the dispersion is $v > r$.

An attempt was made to find whether slow cooling would affect the value of the optic axial angle. Specimens low in soda, heat-treated to give the largest 'sanidine' optic axial angle, would be most likely to respond. After heating specimens A and G to 1100° C. for 50 hours, the optic axial angles were found to be 2V 54·1° and 32·1° respectively. The specimens were then cooled for 70 hours from 1100° C. to 770° C., after which the optic axial angles were 2V 53·1° and 29·7°. Specimen A was heated again for 150 hours at 900° C., when 2V 43·7°. After cooling specimen G for 500 hours from 800° C. to 350° C. it had an optic axial angle of 28·8°.

These results suggest that slow cooling may to some extent reverse the direction of change of optic axial angle, particularly in the region 1000–900° C., but they are not conclusive. In any case the changes are sluggish compared with those that accompany perthitic solution and exsolution between 350° C. and 750° C.

Changes in refractive index.—Accompanying the changes in optic axial angle, the values of γ and β are transposed, whilst the value of α remains almost constant, falling at the most 0·002. Usually the fall in the value of γ was found to be greater than the rise in the value of β.

(*b*) *Changes in the orthoclase-microperthite series with more than 30 % soda-component.*

Changes in optic axial angle.—The equilibrium angle in the symmetry-plane falls with increasing soda-content, while at the same time the felspars become more resistant to change in optic axial angle on heating. Specimen I with 30 % soda-felspar needed 300 hours at 775° C. to reduce the optic axial angle to zero, and 100 hours at 790° C. to reverse it to 2V 20°. Specimen M, with 42 % of soda-felspar, was only changed from 2V 73° to 34° by 300 hours' heating, and specimen Q, with 54 % soda-lime-component, was only changed from 2V 83° to 62° in 300 hours.

It must be remembered that in all specimens with large optic axial angles (including microcline and adularia) a greater relative change in the indices γ and β is required to produce a given change of that angle than when the angle is initially small. With an angle 2V 10–20°

a relative change of one in the fourth decimal place of γ and β corr sponds to a change in the optic axial angle of about 10°, but wh 2V 80°, the change is only about one degree.

However, the fact that these soda-rich specimens are intrinsical more resistant to change is shown, firstly, by the fact that the eq librium angle at 1075° C. falls as the soda-content increases, a secondly, by the resistance to change of specimen P. This has t low initial angle of 2V 38°, but requires 300 hours at 1075° C. reduce the angle further to 2V 15°.

Changes in refractive index.—Prolonged heating at 1075° C. caus changes in the refractive indices of soda-rich microperthites sligh different from those found in the soda-poor forms. In the latter t values of α remained nearly constant, while the values γ and β chan but in the soda-rich varieties all three refractive indices are sligh depressed, apparently because of solution of excess microperthi The drop in refractive index is less in proportion to the amount perthite dissolved than that found during solution in the 350–850° region. If the solution of perthite takes place during the reduct of optic axial angle, the final effect on the refractive indices is a la drop in the value of γ, a smaller drop in the value of α, and a sm rise or drop in the value of β, depending upon the change in the op axial angle and the amount of perthite dissolved. Specimen P, wh is entirely homogeneous above 800° C., shows no decrease in refr tive index, except for the changes which accompany the reduction optic axial angle.

Changes in the extinction-angle.—The medium- and high-soda me bers of the true orthoclase-microperthite series show a small red tion in extinction-angle on heating to 850–900° C., and a further duction on prolonged exposure to higher temperatures. This eff has already been described for Ceylon moonstone (24, p. 34 Specimens with extinctions of 11–12° on (010), after heating to 100 1075° C. show a reduction to about 8°, and those with extinctions 9–10° are reduced to 7–8°. This reduction may be caused by th factors which reduce the optic axial angles, but in some cases change in extinction-angle precedes the change in optic axial ang

Barth (5, p. 72), from his experiments on the potash-soda-felsp concluded that the position of the indicatrix in the homogene members was unaffected by heat-treatment, but the above ea demonstrable changes in extinction-angle show that the position well as the form, of the indicatrix can be modified by heating.

arth used adularia, microcline, and anorthoclase, which are not epresentative of the potash-soda-orthoclase series, any general conlusions drawn from his experiments are likely to be misleading.

(c) *Changes in adularia.*

It has been stated[1] that adularia suffers an irreversible change etween 700° C. and 900° C., the optic axial angle decreasing to zero nd opening out in the symmetry-plane. This statement is based on he work of Des Cloizeaux (9, 10) and Merwin (21), but it is not supported by the work of Kôzu, Barth, or the writer. Kôzu and Suzuki 6, pp. 187–191) heated specimens of adularia to a temperature of 1000° C., and found that the optic axial angle remained unchanged p to about 900° C., after which it declined irregularly with increase f temperature to about 2V 30°. Barth (5, p. 60) also subjected dularia to prolonged heat-treatment. After 400 hours at 1000° C., found that the optic axial angle had declined from 2V 61° to 30° ithout equilibrium being attained.

Similar results have been obtained by the writer for prolonged eating at 1075° C. and higher temperatures. Table II (pl. XVIII) d fig. 6 (p. 464) show the results of heating adularia (specimen B) r 200 hours at 1075° C. The optic axial angle was reduced from 68° to 22° without reaching equilibrium. Heating the same ecimen for 100 hours at 1120° C. reversed the optic axial angle into he symmetry-plane to 2V 30°, with patchy areas having a lower ngle. Tests on further specimens from the same crystal and from hers of similar composition showed an even greater resistance to hange at high temperature, the optic axial angles being reduced only om 68–70° to 40–50° after 300 hours at 1075° C. In view of the w soda-content this resistance to change is remarkable and is only aralleled by the resistance of microcline and the soda-rich orthoclase-icroperthites. The reason for this is undoubtedly connected with e lower temperature of formation.

(d) *Changes in albite.*

The behaviour of the two albites (S and T) towards prolonged heatreatment was somewhat peculiar. After heating to 1075° C. for 50 ours there was a slight reduction of optic axial angle in specimen S, t no change in specimen T. After a further 50 hours' heating T

[1] See, for example, A. N. Winchell, Elements of optical mineralogy. 2nd edit., 33, pt. 2, pp. 361–362.

showed no change, while the optic axial angle of S was reduced fr
2V 100°[1] to about 80°. At the same time the extinction-angle on (0
was reduced in a patchy manner. After 300 hours at 1075° C., sp
men S showed a uniform extinction of 8° on (010); the optic a
angle was then 2V 35–60°, with a change in the direction of the o
axial plane which made it difficult to read the angle accurately.
optic axial angle of specimen T diminished on the same treatment
about 2V 80°. A (010) section showed a regular mosaic of parts
tinguishing at 8° and 18° respectively. The specific gravity of b
specimens fell about 0·006 during the treatment.

It is evident that the changes produced in albite by heat-treatm
are quite different from those produced in the orthoclase-microperth
series. Of the specimens examined, adularia is the only one t
tends to behave like albite; it is significant that field-evidence i
cates a low-temperature hydrothermal origin for both species
compared with a high-temperature origin for the orthoclase-mi
perthites and an intermediate temperature for the microclines.

(*e*) *Changes in microcline.*

In comparison with the corresponding orthoclases, the six mi
clines examined show a characteristic resistance to change on
longed heating. Thus specimens E and H of the orthoclase-mi
perthite series, with approximately the same soda-felspar conten
the microclines, show axial angles 2V 29° and 22° in the symme
plane after 200 hours at 1075° C. The optic axial angles of the mi
clines, by the same treatment, drop from 2V 70–80° to 30–50°, the o
axial plane remaining normal to (010). Microclines U and V sho
unexpected changes after heating for 300 hours at 1075° C.; the o
axial angles were reversed into the symmetry-plane to 2V 44° and
respectively. At the same time the fine microcline twinning vis
on (001) was destroyed. It is seen that these glassy or semi-gl
microclines are more easily sanidinized than adularia of corresp
ing composition.

Previous attempts to convert microcline to the homogeneous m
clinic orthoclase form by heat-treatment have yielded conflic
results. Mäkinen (20, pp. 125–127) and previous investigators fo
that the cross-hatch structure was not destroyed on heating to nea
melting-point of the felspar.

[1] In conformity with the orthoclase-microperthite series, the recorded
axial angle is that one which includes the minimum axis of the indicatrix.

Dittler and Köhler (11, pp. 250–258) by heating microcline-microrthite for 500–700 hours at 1000° C. found that the cross-hatching sappeared, leaving a mineral with the characters of orthoclase. ore recently, Barth (5, p. 63) heated low-soda microcline for 300–0 hours at 1000° C., after which the mineral was still triclinic.

These variable results probably represent the difference in behaviour different microcline specimens. The writer's results show that the ni-glassy, finely twinned microclines are much less resistant to at-treatment than the coarsely twinned varieties with 'vein' perte, especially when the optic axial angle is initially large. There ittle doubt that prolonged heating at 1075° C. would convert even latter into the homogeneous sanidine form. The character of the nsformation seems to be more abrupt than that found in the hoclase-microperthite series, and resembles the changes undergone albite.

(f) Effect of slow cooling on 'sanidinized' felspars.

It has been suggested on p. 473 that the homogeneity of the natural a-bearing sanidines cannot be due, as is often assumed, to rapid ling through the temperature range of perthitic exsolution, since rock-cooling rates can have been so rapid as those that have been d necessary, in the writer's experiments, to prevent exsolution. natural sanidines are invariably forms with small optic axial gles. It appears probable that the size of the optic axial angle is easure of some modification of the atomic framework, which is cause of the capacity for holding the soda-felspar in permanent d solution. In support of this it was found that artificially idinized' felspar, on cooling for 500 hours from 850° to 350° C., wed a smaller return of refractive index (indicating less exsolution) n did specimens of the same felspar that had not been heated ve 800° C. and that thus had larger 'normal' optic axial angles. ig. 18 (p. 472) shows these results, the upper curve giving the oration of refractive index on slow cooling for non-sanidinized cimens, the lower curve being for the same specimens on slow ling after having been converted to the sanidine form. In each the number in brackets near the plotted point is the optic axial le. For any specimen, the lower the optic axial angle of the idinized form, the smaller is the return of refractive index. Thus form with the low optic axial angle holds the soda-component in tion during slow cooling through the range of perthitic exsolution.

Sanidine from Eifel (specimen G) with the low optic axial angl
2V 24° shows a drop in refractive index of only 0·0003–4 on hea
to 800° C. Two anorthoclases at present under examination, f
Drachenfels, Siebengebirge, Rhine, and Haddington, Scotland,
low-angle specimens with higher soda-contents. Their analyses
gether with their approximate compositions, are set out below.

	Siebengebirge.	Haddington.
SiO_2	63·90 %	62·85 %
Al_2O_3	20·09	20·43
Fe_2O_3	0·79	0·67
CaO	0·62	1·30
K_2O	10·10	9·83
Na_2O	4·02	4·02
Loss	0·62	0·74
	100·14	99·84
Composition (Wt. %)	$Or_{62}Ab_{35}An_3$	$Or_{59}Ab_{35}An_6$
Symbol on fig. 2 (p. 458)	Si	Ha

The refractive index of the Siebengebirge specimen, with an o
axial angle of 2V 33°, drops by 0·0003 on heating to 800° C., w
the Haddington specimen, with 2V 34°, shows a drop of 0·0005. I
are free from schiller and perthitic inclusions. It is clear that
these compositions and optic axial angles the saturation point is
appreciably exceeded in the exsolution temperature range.

These anorthoclases are much more resistant to change than
sanidines. Specimen G (Eifel sanidine), after heating to 1075° C
300 hours, showed a change of optic axial angle from 2V 24° in
plane normal to (010) to 2V 29° in the symmetry-plane. The s
treatment reduced the optic axial angle of the anorthoclase by
5–7° (fig. 2, p. 458). A similar resistance to change has been not
in other soda-rich, low-angle anorthoclases.

As the optic axial angle increases, mutual saturation of the
felspars in the range of 750–350° C. is ultimately exceeded, and s
of the soda-felspar separates as perthite. The higher the s
content, the lower the optic axial angle when this occurs. Interes
examples are specimen P (Korea) and the phenocrysts from
Sparling Gulch rhyolite (24, p. 337). The composition and
axial angles of these felspars are such that for temperatures b
800° C. the saturation point has been exceeded, but at this temp
ture they both become clear and homogeneous. Orthoclase ph

wsts from a riebeckite-trachyte, Berkum, Rhine,[1] have a faint blue niller that disappears on heating to 850° C., with concomitant drop specific gravity and refractive index, and a slight rise in optic ial angle.

For felspars with still higher optic axial angles and high soda-tent the saturation point may be exceeded even at a higher nperature than 800° C. Thus specimens J, L, M, and N of the hoclase-microperthite series all possess lower soda-content than Korea specimen P, but have higher optic axial angles (72–83°). ne of these specimens becomes clear and homogeneous at 800° C., though the changes in refractive index indicate that the greater rt of the soda-component has been taken into solution.

(*g*) *The continuous nature of the changes in the orthoclase-microperthite series.*

An important deduction from the results described above is that e changes brought about by the heat-treatment of members of the hoclase-microperthite series are continuous, the physical properties, equilibrium, varying progressively with the temperature.

The sudden change in expansion and other properties observed by zu and Saiki (17) at temperatures of 450–500° C., at 750° C., and at 950° C., and the changes observed by Merwin (21) at 900° C., can included in these general changes. Thus between 500° and 650° C. roperthite begins to go rapidly into solution, and 700° C. is the perature at which saturation is nearly complete for specimens h up to 30 % of soda-component. The temperature of 900–950° C. that at which the optic axial angle of many specimens is first ected.

It is possible that some slight change in the atomic structure of felspar at or near these temperatures is responsible for the sudden nge in the rate of alteration, but, if so, it does not show as a nge in the *form* of the indicatrix. Moreover, these temperatures are fixed, but vary very considerably with the type and composition he felspar. Hence the available evidence does not support the ief that an inversion occurs at these temperatures, as Alling (2)

[1] Belyankin (6) described this felspar as anorthoclase showing 'cross-hatch' ning on basal sections. My specimen is schillerized and microperthitic. structure seen on basal flakes is due to microperthite. Belyankin's analysis es closely with mine. SiO_2 64·94, Al_2O_3 20·27, Fe_2O_3 0·45, FeO n.d., CaO 0·67, trace, BaO n.d., K_2O 6·12, Na_2O 6·82, loss n.d., total 99·27.

and Winchell (28) have assumed. Except for a possible break to microcline type in the formation temperature region of 600–750° for adularia at a lower temperature, and for albite at a very h temperature, the evidence points strongly towards a gradual cha in physical properties with change in equilibrium temperature composition.

IX. X-rays and Felspar Structure.

(*a*) *The identical structure of orthoclase and sanidine.*

X-ray examination of orthoclase and sanidine by Schiebold and Taylor (25, 26) fails to show a difference in their struct Taylor, realizing that some difference must exist to account for t optical dissimilarity, says (26, p. 494): 'A fact of some importa which bears upon this question is that optical examination is m more sensitive than X-ray examination to a change in symm and to small distorting forces.'

Kôzu and Suzuki observed the effect of heat upon the optic a angle of sanidine, but could find no corresponding change in struc by X-ray examination. They concluded that the effect 'is du changes in the arrangement of the dispersion electrons compo the atoms of the crystals, not to the atomic arrangement' (15, p. 2

It is unlikely that small changes of the above nature could acc for the pronounced differences in permanent solubility for s component between the two forms of potash-felspar. Again, reversal of the optic axial angle in the soda-poor potash-felsp from about 40° in the plane perpendicular to (010) to about 55 the symmetry-plane, involves a transposition of the refractive ind γ and β, with a relative change in their values of about 0·0 This change in the direction of maximum refractive index for same kind and number of atoms in the framework must mean some modification of the structure has occurred.

(*b*) *The structure of felspars and its bearing upon perthitic solutio*

From the work of Machatschki (19) and Taylor comes the sug tion that the felspar structure is one of linked chains of tetrah of AlO_4 and SiO_4, with the alkali metals distributed as cations in interstices of the oxygen atom arrangement. According to Ta (26, p. 479) albite has the same structure as sanidine (orthocla except for a slight rotation and closing up of the chains round

smaller sodium ions. In perthitic felspars he suggests that 'The tetrahedron framework may thus be continuous throughout the lamellar crystal, but with regions of greater extension of the chains, and lesser extension, which appear optically as orthoclase and albite lamellae respectively' (26, p. 489).

It is no longer necessary to assume that the whole of the albite or orthoclase molecule migrates during the formation of perthite, only that the sodium and potassium ions undergo translation. On slow cooling, the smaller sodium ions tend to segregate, and when this segregation has reached a certain value, the tetrahedron framework contracts in these areas and rotates a little, and a patch of albite is produced. Re-solution of the perthite structure on heating would represent a reversal of this process.

It has been shown (24, pp. 298–303) that the microperthitic structure in soda-rich specimens of the Ceylon or Burma moonstone type is of two kinds: (*a*) the ordinary fine 'film' or 'string' micro- or cryptoperthite; and (*b*) a coarser 'shadow' perthite in lenses which lie approximately in the plane (100), and which embrace a number of the finer microperthitic lamellae. The 'shadow' perthite is generally present in normal members of the series when the soda-content is in excess of 25–30 %. It is more difficult to destroy by heat-treatment than the 'film' type of perthite, and often persists after prolonged heating at 1000° C. It seems probable that the 'shadow' perthite represents an early, high-temperature separation into areas richer and poorer in sodium ions. It may be that at temperatures down to 800–850° C. the sodium ions, corresponding to the excess of soda-component over 30 %, segregate and form regions in which the structure is a little denser, or nearer albite, than the potash-rich areas. The optical difference between these two forms cannot be great, since they do not produce schiller, and there is only a slight change in optical properties when they are taken into solid solution.

Another peculiarity of the orthoclase series (see p. 460) is that the extinction on (001) tends to be straight, and the obtuse bisectrix tends to remain normal to (010), even in soda-rich specimens. Since albite shows a considerable deviation in both these respects, one would expect that a lamellar mixture of orthoclase and albite would show a proportional deviation. That this is not seen might be explained: (*a*) by the special manner and direction in which the albite lamellae have separated from solid solution, involving a minimum disturbance of the tetrahedron framework as a whole; (*b*) by the tetrahedron

framework within the albite lamellae still possessing certain ortho clase characteristics, i.e. shrinkage may have taken place without rotation of the structure.

The latter explanation would account for the ease and rapidity with which these 'film' types of microperthite go into solution as compared with the coarser 'primary' or 'vein' perthite. The variety, most common in the microclines, is generally believed to have crystallized directly from solution, and, as a result, may possess a true albite structure of greater rigidity. These coarse lamellae invariably show multiple albite-twinning, which the writer has not yet found in 'film' perthite of exsolution origin. These facts are in better agreement with the view that perthitic solution and exsolution are caused by a translation of the metallic ions rather than of the felspar molecules themselves.

X. An Attempted Explanation of the Experimental Results

An attempt will now be made to review the experimental results described above in the light of the X-ray explanation of the felspar structure.

(*a*) *Felspars with 0–30 % of soda-component.*

The stable form at high temperatures of the potash-soda-felspars with less than 30 % of soda-component is the sanidine type, with the optic axial plane parallel to (010). For a given temperature, the optic axial angle in this plane decreases with increase in soda-content. Conversely, with a constant soda-content, the optic axial angle decreases with lowered temperature of formation. Both these changes finally cause the optic axial plane to become perpendicular to (010), while further increase in soda-content, or a lowered temperature of formation, increases the optic axial angle towards the albite figure.

In potentially perthitic felspars this tendency reaches a maximum while the felspar is still homogeneous. Perthitic exsolution causes only a uniform change in the three refractive indices without affecting the optic axial angle. It may be assumed from this that the sodium ions in the homogeneous felspars produce the same average distortion effect as they do when separated as perthite lamellae. Exsolution causes no further distortion of the framework, only a uniform shrinkage in the spaces occupied by the separated soda-felspar

mellae, which thus acquire the refractive indices and density of bite, without apparently taking on full triclinic symmetry.

If the optic axial angle is not at a maximum just above the mperature of exsolution, some of the soda-felspar will remain in lid solution, even though cooling through the exsolution range is ow. For instance, the homogeneous felspars of Siebengebirge and addington, with optic axial angles of about 35°, hold some 35 % of da-felspar.

(*b*) *Felspars with more than 30 % soda-component.*

In the high-angle, soda-rich microperthites the temperature of rthitic exsolution is above that at which the optic axial angle tains its maximum. In order to render such felspars homogeneous, is necessary to heat them for long periods at a temperature at ich the optic axial angle is considerably reduced. These felspars st have been formed at a higher temperature, with a small optic al angle, which has increased to its present value by very slow oling and with exsolution.

That this cooling must be exceedingly slow is shown by the 'sub-rmal' optic axial angles of such felspars as P and K, from hypa-ssal rocks. In volcanic rocks, although their cooling is slow in mparison with any experimental rates, the optic axial angle is ally nearer the minimum than the maximum possible.

The changes in the oblateness of the indicatrix which give rise to changes of optic axial angle are not very great, and any corre-nding change in the form of the tetrahedron framework would y be slight. This may explain why X-ray examination has so failed to distinguish a difference in structure between low-angle idine and high-angle orthoclase. Small as these changes are, y control the behaviour of the potash-soda-felspars in the ex-ution temperature region by determining whether the felspar shall ain homogeneous, with the sodium and potassium ions dispersed nly throughout the structure, or whether the ions shall segregate form respectively albite and orthoclase perthite lamellae.

XI. (*a*) *Diagrammatic representation of the microperthitic field.*

The relations between the optic axial angle, the degree of ex-ution, and the soda-felspar content are indicated by the curves of 19. For a given composition, forms with high optic axial angles

show complete exsolution, but in corresponding low-angle forn exsolution is completely inhibited.

The curve *DCE* shows the optic axial angles of normal felspars the orthoclase-microperthite series, and *HI* the probable equilibriu angles of the sanidine-anorthoclase series at a temperature of 1075°

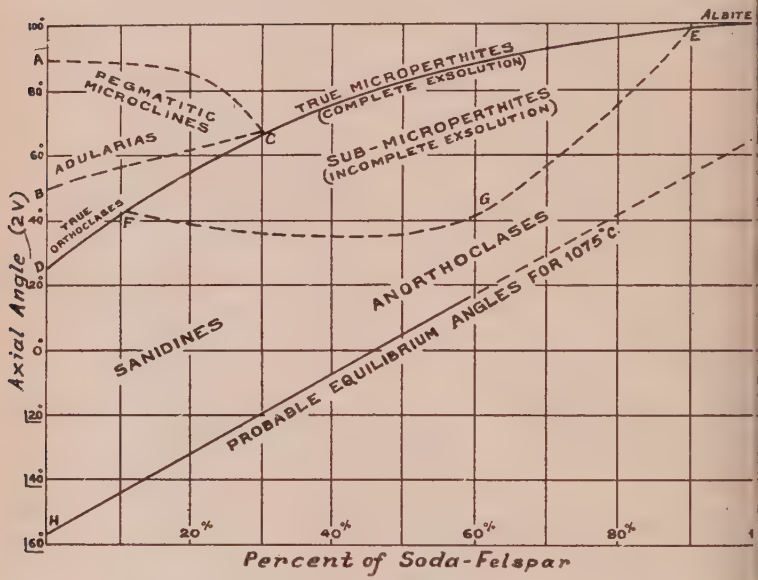


FIG. 19. Optic axial angles and felspar forms.

The curve *FGE* represents the approximate boundary between co plete and incomplete homogeneity; all the microperthitic orthocl forms fall within the area *FCEG*. The closer the optic axial an is to the upper line *FCE*, the greater the degree of exsolution a the more complete the perthitic separation.

In the area *ACB* are included the microclines and adularias, wh optic axial angles are all considerably higher than those of the c responding orthoclase-microperthites. This is probably connect with their lower temperature of crystallization. Perhaps the tre of the orthoclase boundary towards *D* may indicate the inability the solid phase produced at relatively high temperature to maint perfect equilibrium of optic axial angle with falling temperatur If this is true *CD* represents metastable forms; the true stable for lying close to the line *CB*. It is also possible that the changes

tomic structure, which must accompany the increase in optic axial ngle, favour the formation of the triclinic microcline form. This uestion will be referred to when discussing the origin of pegmatitic icroclines in the second part of the paper.

(*b*) *A possible discontinuity in the high-soda region.*

In order to draw more precisely the boundary between the homo-neous and perthitic fields in the high-soda region (i.e. the right-and portion of the curve *FGE*, fig. 19), two specimens described by . D. Mountain (22, p. 336) have been referred to, and three addi-onal specimens have been examined. The results and analyses are bulated below.

	1.	2.	3.	4.	5.
SiO_2 ...	60·08	64·80	64·33	64·76	62·79
TiO_2 ...	0·97	—	—	—	—
Al_2O_3 ...	19·99	21·14	20·94	21·50	22·12
Fe_2O_3 ...	1·57	0·68	0·20	0·54	0·36
FeO ...	1·68	—	0·58	—	0·41
CaO ...	2·21	1·18	2·01	1·94	3·76
MgO ...	0·72	0·10	—	0·18	—
K_2O ...	4·45	5·26	4·71	3·88	2·98
Na_2O ...	7·03	6·94	7·22	7·44	7·35
Loss ...	n.d.	0·20	0·37	0·10	0·26
	98·70	100·30	100·36	100·34	100·03
Comp. (wt. %)	$Or_{27}Ab_{62}An_{11}$	$Or_{32·5}Ab_{62·5}An_6$	$Or_{28}Ab_{62}An_{10}$	$Or_{24}Ab_{66}An_{10}$	$Or_{19·5}Ab_{61·5}An_{19}$
Optic axial angle (2V) ...	80°	57·5°	51°	53·5°	62°
Symbol on fig. 20	Lv	Ky	Km	Pa	Eb

. Schillerized felspar with fine microperthitic and composite structure; optic al angle sub-normal. Phenocrysts from larvikite. Oslo area, Norway. Analyst, Spencer.

. Homogeneous non-schillerized felspar, with sub-normal optic axial angle. nocrysts from kenyte, Mt. Kenya, East Africa. Analyst, E. Spencer.

. Homogeneous non-schillerized felspar, with sub-normal optic axial angle. nocrysts from kenyte, Mt. Kenya, East Africa. Analyst, E. D. Mountain.

. Homogeneous non-schillerized felspar, with sub-normal optic axial angle. ated phenocrysts. Pantelleria. Analyst, E. Spencer.

. Homogeneous non-schillerized felspar, with sub-normal optic axial angle. nocrysts, Mt. Erebus, Antarctica. Analyst, E. D. Mountain.

t will be seen that all five specimens are relatively rich in lime, l it appears that orthoclase-microperthite rich in soda but poor lime is uncommon. Phenocrysts in the trachyte of Berkum,

Rhine,[1] provide the most sodic, lime-poor specimens that I have y investigated, with a composition of $Or_{37}Ab_{60}An_3$.

E. D. Mountain (22, p. 340) has shown that the felspar phenocry from Mt. Erebus and Mt. Kenya can be included in a series rangi between $Ab_{65}Or_{35}$ and $Ab_{65}An_{35}$,[2] whose end-members are the Berku anorthoclase and oligoclase-andesine. The series has continuc optical and crystallographic properties. In fig. 20 the line *CD*

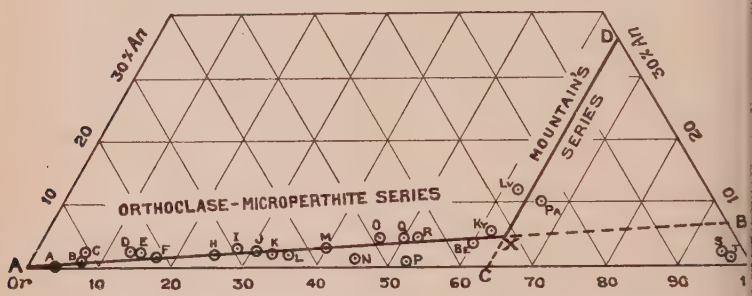


Fig. 20. Orthoclase-microperthites and E. D. Mountain's series.

the compositional triangle represents this series, and the orthocla microperthite series is shown by the line *AB*. The intersection these lines at *X* corresponds approximately to the composition the Berkum anorthoclase. The three new specimens Lv, Ky, a Pa all lie near *CD*.

Johansson (12), Asklund (4), and Alling (2) have plotted analyses of a large number of felspars on the Or–Ab–An triang and it is noteworthy that the lines *AX* and *XC* of fig. 20 lie appro mately in the directions of the maximum density of occurrence potash-bearing felspars in these diagrams.

These facts support the view that there is a discontinuity in potash-soda-felspar series above 60 % of soda-component, with deviation towards oligoclase-andesine. It appears that, at crystallizing temperature of these felspars, the orthoclase struct can accommodate up to 50–60 % of soda-component with only a slig distortion towards the albite form, and that the albite structure accommodate up to 20–30 % of potash-component with some modifi tion towards the orthoclase form, but that between these limits, a

[1] See footnote, p. 483, for analysis.

[2] These compositions are expressed in molecular percentages, as given E. D. Mountain. Those tabulated above are weight percentages.

ith the amount of lime usually present in the crystallizing magma, omogeneous potash-soda-felspars are not produced.

Summary.

A series of potash-soda-felspars of the orthoclase-microperthite type, lected with increasing soda-contents up to 60 %, have been examined d found to exhibit a progressive relationship between chemical mposition and physical properties. Albite ($Ab_{97}An_2Or_1$) conforms physical properties to the soda end-member of the series.

Adularia and microcline do not strictly belong to the series, the tic axial angle 2V and the birefringence $\gamma - \beta$ being too high. On e other hand, the sanidines and anorthoclase felspars have lower fractive indices and a lower optic axial angle than orthoclase-croperthites of corresponding composition. This low optic axial gle is the result of relatively rapid cooling through the temperature ge of 1050–900° C., and the ensuing modification of the internal ucture enables the felspar to hold the soda-component in complete d solution on further cooling through the perthite exsolution mperature range (850–350° C.), however slow the cooling through t range may be.

The microperthite of the orthoclase-microperthite series is of the solution type, and can be taken into solid solution again by ting for some time to 750–800° C., followed by rapid cooling. the same time, the schiller is more or less destroyed, and the ecific gravity and the refractive indices are reduced, the reduction ng roughly proportional to the amount of microperthite taken solution. Providing that the optic axial angle has not been uced by prolonged heating at high temperatures, the microperthite y be in part reprecipitated by very slow cooling; the schiller and croperthite structure reappear and the drop in specific gravity d refractive index are in part restored.

In all cases where the optic axial angle is normal and microperthite olution complete, the angle remains unaltered during the refrac- index changes which accompany the solution of the microperthite heat-treatment. If the optic axial angle is sub-normal and ex- ution of the microperthite is incomplete—as with Korea moonstone, —the solution of the microperthite is accompanied by a slight in the axial angle.

Recent X-ray examination of felspar structures has led to the

suggestion that microperthitic exsolution represents a local segreg tion of the sodium and potassium ions within the silica-alumi framework followed by a contraction and slewing of the framewo in the areas rich in sodium ions. This view explains the relati ease with which the microperthitic changes can be brought about heating.

The optic axial angles of potash-soda-felspars are reduced prolonged heating at high temperatures. Specimens with less th 40 % of soda-felspar can be completely 'sanidinized' or convert into the abnormal type of felspar with the optic axial plane paral to the plane of symmetry. The equilibrium value of the optic ax angle, for a temperature of 1075° C., depends on the chemical co position, the relationship being approximately linear between 2V ((0 % soda-felspar) and 2V 0° (40–45 % soda-felspar). Microcline c be converted to the abnormal form by heating at 1075° C. for a lo period; at the same time the cross-hatch twinning is destroyed.

Attempts to reverse this process and to restore the original op axial angles to 'sanidinized' felspars, by cooling them very slov through the high-temperature range, have not given positive resul but the indications are that a part of the change may be reversi in laboratory cooling times.

In conclusion, I wish to thank Professor P. G. H. Boswell for help and advice and Mr. R. Walls of the Imperial College of Scier and Technology, London, for assistance in the preparation of t paper; also members of the Geological Survey of India, especia Sir Lewis Fermor and Dr. J. A. Dunn, for their kind help a criticism; and Messrs. K. B. Sen and B. P. Gupta, of Messrs. B & Co., Calcutta, for much help with the chemical analyses a physical determinations.

Addendum.—When the MS. was in its final form, the write attention was drawn to the recent paper by C. T. Barber (Min. Ma September 1936, this vol., p. 343). Barber heated plagioclase felsp for long periods at 1000° C., and found that the optic axial angle albite was not significantly affected by this treatment. It is probal that the low temperature of the experiment was responsible for t negative result. Prof. W. L. Bragg informs me that unpublish investigations on the behaviour of metallic alloy-systems show th the rate of transformation falls off greatly with decreasing tempe tures. It is likely that similar effects would be found in the felspa

From tests that I have made on potash-oligoclase, it seems that the presence of appreciable quantities of lime in the felspar structure retards the change even on prolonged heating at 1075° C.

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Table I

Chemical Composition of the Potash-Soda-Felspars Examined.

A. Orthoclase-Microperthites

	Specimen	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	BaO	K_2O	Na_2O	Loss	Total	Potash Felspar	Soda Felspar	Lime Felspar	Total
A	Yellow Orthoclase *	64·40	18·70	0·62	0·09	Tr.	Tr.	–	16·14	0·46	–	100·41	95·39	3·89	–	99·28
B	Adularia St. Gothard	64·28	19·19	0·09	–	0·11	0·10	0·11	15·30	0·92	0·36	100·46	90·43	7·78	Lime-Felspar 13 Ba- " 0·27	99·03
C	Burma Colourless *	63·66	19·54	0·10	–	0·50	–	–	15·60	0·80	–	100·20	92·20	6·76	2·50	101·46
D	Burma Blue No. I *	65·30	18·84	0·16	–	0·34	–	–	14·18	1·62	–	100·44	83·80	13·69	1·70	99·19
E	Kalahandi Orthoclase	63·75	19·10	0·48	–	0·35	–	–	13·91	1·74	0·62	99·96	82·21	14·71	1·80	98·72
F	Burma Blue No. II *	65·14	19·60	0·10	–	0·45	–	–	13·07	2·20	–	100·56	77·24	18·60	2·25	98·09
G	Eifel Sanidine	64·70	18·56	0·20	Tr.	Tr.	Tr.	1·31	12·72	2·46	0·42	100·37	75·18	20·79	Ba.-Felspar 3·20	99·17
H	Burma White No. I *	64·02	19·53	0·32	Tr.	0·53	0·16	–	12·12	3·02	0·28	99·83	71·63	25·53	1·65	98·81
I	Ceylon Blue No. I	64·66	19·72	0·08	–	0·34	Tr.	–	11·72	3·42	0·18	100·12	69·27	28·91	1·70	99·88
J	Ceylon Blue No. II	65·16	19·01	0·19	–	0·17	0·10	–	11·07	3·78	0·40	99·88	65·43	31·95	0·85	98·23
K	Burma Blue No. III	64·40	19·80	0·10	–	0·36	Tr.	–	10·92	4·00	0·50	100·08	64·54	33·81	1·80	100·15
L	Kandy White No. I *	64·97	19·77	0·23	–	0·20	0·15	–	10·42	4·24	0·37	100·35	61·58	35·84	1·00	98·42
M	Ceylon Blue No. III	64·50	20·25	0·47	–	0·43	Tr.	–	9·60	4·72	0·28	100·30	56·74	39·90	2·40	99·04
N	Burma White No. II	65·40	19·89	0·27	–	0·14	Tr.	–	8·92	5·30	0·30	100·22	52·72	44·80	0·70	98·22
O	Burma Black No. I *	64·76	19·96	0·08	Tr.	0·84	Tr.	–	8·12	5·54	0·54	99·84	47·99	46·83	4·20	99·02
P	Korea Blue	66·38	18·92	0·40	Tr.	0·10	–	–	7·90	6·06	0·50	100·26	46·69	51·23	0·50	98·42
Q	Burma Black No. II *	65·22	19·58	0·08	Tr	0·84	Tr.	–	7·64	5·88	0·56	99·80	45·15	49·70	4·20	99·05
R	Fredricksvärn	64·98	19·64	0·64	–	0·84	Tr.	–	7·33	6·00	0·40	99·83	43·32	50·72	4·20	98·24

B. Albites

S	Amelia *	67·24	20·48	0·12	–	0·25	–	–	0·44	11·43	0·30	100·26	2·60	96·62	1·25	100·47
T	Kodarma	67·10	20·44	0·10	–	0·03	–	–	0·24	11·62	0·40	99·93	1·42	98·22	0·40	100·04

C. Microcline-Microperthites

U	Kodarma (White) No. I	64·38	19·50	0·11	–	0·21	Tr.	–	14·32	1·48	0·28	100·35	84·63	12·51	1·40	98·54
V	Kodarma (Green) No. II	64·38	19·48	0·12	–	0·21	Tr.	–	14·02	1·72	0·30	100·24	82·86	14·54	1·10	98·50
W	Patna No. I	64·64	19·52	0·13	–	0·08	Tr.	–	13·58	2·10	0·16	100·21	80·26	17·75	0·40	98·41
X	Patna No. II	64·26	19·72	0·10	–	0·31	Tr.	–	13·42	2·28	0·18	100·27	79·31	19·27	1·55	100·13
Y	Ryagada	64·20	19·10	0·40	–	0·34	–	–	12·76	2·60	0·72	100·12	75·41	21·98	1·70	99·09
Z	Kodarma (White) No. III	64·22	18·78	0·66	–	0·31	Tr.	–	13·16	2·38	0·60	100·11	77·78	20·12	1·55	99·45

Table II

Physical Properties of the Potash-Soda-Felspars Examined.

A. Orthoclase-Microperthites

	Specimen	Ordinary Readings: Refractive Indices α	β	γ	Axial Angle Measured	Axial Angle Calculated	Extinction on (010)	Extinction (γ–α)	Birefringence	Specific Gravity	Effect of Heating to 850° C. and Quickly Cooling: Refractive Indices α	β	γ	Drop in Refractive Indices	Axial Angle	Axial Gravity	Specific Gravity	Effect of Prolonged Heating to 1075° C.: Time Hours	α	β	γ	Axial Angle	Axial	Extinction on (010)	Maximum Angle Change and Conditions: Time Hours	Temperature	Axial Angle	Whether Equilibrium or not	Dispersion
A	Yellow Orthoclase	1·5194	1·5237	1·5241	34·8°	33·9°	5·2°	·0047	2·5625	1·5194	1·5237	1·5241	Nil	No Change	2·5625	300 H	1·5192	1·5230	1·5240	53·8° R	5·2°	24 H	1120–30° C	58° R	Equilibrium	υ > ρ
B	Adularia St. Gothard	1·5192	1·5228	1·5245	68·4°	68·9°	5·25°	·0053	2·5661	1·5191	1·5226	1·5243	·0002	"	2·5648	200 H	1·5190	1·5230	1·5233	22·0° R	N.D.	100 H	"	30° R	Not Equilibrium	"
C	Burma Colourless	1·5188	1·5230	1·5236	43·6°	41·5°	5·3°	·0048	2·5632	1·5188	1·5230	1·5236	Nil	40·5° Z	2·5622	300 H	1·5187	1·5227	1·5233	44·8° R	5·3°	24 H	"	53° R	Equilibrium	"
D	Burma Blue No. I	1·5199	1·5240	1·5248	46·2°	47·6°	6·2°	·0049	2·5673	1·5190	1·5231	1·5239	·0009	No Change	2·5635	300 H	1·5189	1·5233	1·5236	33° R	N.D.	300 H	1075° C	33° R	Near Equilibrium	"
E	Kalahandi Orthoclase	1·5201	1·5239	1·5251	57·6°	58·5°	7·5°	·0050	2·5697	1·5191	1·5230	1·5242	·0010	"	2·5663	200 H	1·5190	1·5232	1·5235	29° R	"	90 H	1090° C	34° R	"	"
F	Burma Blue No. II	1·5206	1·5249	1·5260	52·9°	53·6°	7·0°	·0054	2·5712	1·5192	1·5235	1·5246	·0014	"	2·5658	300 H	1·5192	1·5236	1·5240	28° R	"	12 H	1120–30° C	35° R	Equilibrium	"
G	Eifel Sanidine	1·5202	1·5247	1·5249	24·0°	23·8°	5·8°	·0047	2·5763	1·5200	1·5244	1·5246	·0002	2·2°	2·5752	300 H	1·5199	1·5242	1·5247	29° R	"	10 H	"	32° R	"	"
H	Burma White No. I	1·5220	1·5262	1·5277	61·5°	61·6°	7·7°	·0057	2·5831	1·5203	1·5245	1·5260	·0017	No Change	2·5752	100 H	1·5203	1·5248	1·5250	17° R	6·5°	200 H	1075° C	22° R	"	"
I	Ceylon Blue No. I	1·5217	1·5259	1·5279	69·1°	69·0°	9·5°	·0062	2·5778	1·5192	1·5233	1·5254	·0025	70·7° Z	2·5651	300 H	1·5190	1·5237	1·5237	Nearly	6·9°	100 H	1090° C	20° R	Near Equilibrium	"
J	Ceylon Blue No. II	1·5216	1·5257	1·5282	75·0°	75·8°	10·5°	·0066	2·5801	1·5192	1·5233	1·5258	·0024	75·5° Z	2·5669	300 H	1·5191	1·5240	1·5240	16° R	N.D.	300 H	1075° C	16° R	"	"
K	Burma Blue No. III	1·5220	1·5265	1·5280	61·4°	59·9°	8·5°	·0060	2·5781	1·5199	1·5243	1·5259	·0021	62·2° Z	2·5674	300 H	1·5198	1·5246	1·5250	20·0° R	"	300 H	"	20·0° R	Not Equilibrium	ρ > υ
L	Kandy White No. I	1·5220	1·5262	1·5284	72·0°	71·6°	10·5°	·0064	2·5819	1·5195	1·5237	1·5260	·0025	73° Z	2·5690	100 H	1·5194	1·5239	1·5248	48° R	7·5°	100 H	"	48° R	"	"
M	Ceylon Blue No. III	1·5232	1·5274	1·5299	73·7°	75·1°	10·5°	·0067	2·5848	1·5210	1·5251	1·5276	·0023	75·5° Z	2·5718	200 H	1·5206	1·5255	1·5263	45° R	7·6°	300 H	"	34° R	"	"
N	Burma White No. II	1·5230	1·5270	1·5302	83·5°	83·5°	11·0°	·0072	2·5890	1·5206	1·5248	1·5280	·0022	84·5° Z	2·5772	100 H	1·5202	1·5255	1·5258	34° R	N.D.	200 H	"	24° R	"	"
O	Burma Black No. I	1·5256	1·5296	1·5326	82·8°	81·6°	11·7°	·0070	2·5950	1·5237	1·5277	1·5308	·0019	83·5° Z	2·5856	100 H	1·5231	1·5248	1·5296	66° R	"	250 H	"	54·5° R	"	"
P	Korea Blue	1·5228	1·5284	1·5292	39·1°	41·3°	8·7°	·0064	2·5773	1·5210	1·5263	1·5272	·0020	45·2° Z	2·5687	300 H	1·5209	1·5265	1·5267	15° R	8·3°	300 H	"	15° R	Near Equilibrium	"
Q	Burma Black No. II	1·5258	1·5299	1·5330	81·75°	81·7°	11·6°	·0072	2·5960	1·5241	1·5281	1·5311	·0018	83·2° Z	2·5864	100 H	1·5238	1·5283	1·5303	72° R	7·9°	300 H	"	62° R	Not Equilibrium	"
R	Fredricksvärn	1·5255	1·5301	1·5324	71·3°	70·4°	11·7°	·0069	2·5948	1·5235	1·5281	1·5305	·0020	73·5° Z	2·5859	300 H	1·5221	1·5282	1·5293	49·8° R	N.D.	300 H	"	49·8° R	"	"

B. Albites

S	Amelia	1·5292	1·5328	1·5392	98·2°	97·8°	18·8°	·0100	2·6266	1·5292	1·5328	1·5392	Nil	98·2° Z	2·6266	300 H	N.D.	N.D.	N.D.	35·6° R	9°	300 H	"	35·6° R	Near Equilibrium	N.D.
T	Kodarma	1·5285	1·5326	1·5389	101°	102°	19·5°	·0104	2·6280	1·5285	1·5325	1·5389	"	101° Z	2·6280	300 H	"	"	"	36° R	18°	300 H	"	77°	Not Equilibrium	"

C. Microcline-Microperthites

U	Kodarma (White) No. I	1·5195	1·5232	1·5255	76·2°	76·5°	7·5°	·0060	2·5692	1·5190	1·5228	1·5250	·0005	No Change	2·5688	300 H	1·5189	1·5232	1·5238	44·2° R	N.D.	300 H	1075° C	44·2° R	Near Equilibrium	υ > ρ
V	Kodarma (Green) No. II	1·5203	1·5241	1·5256	63·5°	64·3°	6·0°	·0053	2·5736	1·5197	1·5236	1·5251	·0005	"	2·5733	300 H	1·5194	1·5238	1·5238	16° R	N.D.	300 H	"	16° R	Not Equilibrium	"
W	Patna No. I	1·5202	1·5237	1·5264	81·5°	82·4°	7·5°	·0062	2·5757	1·5192	1·5228	1·5255	·0009	"	2·5673	100 H	1·5190	1·5230	1·5247	66·0° R	6·4°	300 H	"	53·0° R	"	ρ > υ
X	Patna No. II	1·5206	1·5243	1·5266	76·0°	76·4°	7·5°	·0060	2·5747	1·5193	1·5231	1·5254	·0012	"	2·5670	200 H	1·5189	1·5232	1·5238	38° R	6·6°	300 H	"	27° R	"	"
Y	Ryagada	1·5204	1·5240	1·5265	79·9°	79·4°	7·5°	·0061	2·5771	1·5191	1·5226	1·5251	·0014	"	2·5689	300 H	N.D.	N.D.	N.D.	51° R	N.D.	300 H	"	51° R	"	"
Z	Kodarma (White) No. III	1·5205	1·5245	1·5265	71·8°	70·6°	N.D.	·0060	2·5706	1·5190	1·5230	1·5250	·0015	"	2·5512	100 H	1·5188	1·5232	1·5240	45° R	"	200 H	"	39° R	"	"

The composition and paragenesis of the biotites of the Carsphairn igneous complex.

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[Read November 5, 1936; communicated by Professor C. E. Tilley.]

THE Cairnsmore of Carsphairn igneous complex (1) is the smallest of the larger Caledonian intrusions of the Southern Uplands of otland. The intrusion is composite, consisting of a central granite, llowed by successive zones of granite-tonalite hybrid, tonalite, and ic hybrids. The complex began with the intrusion of a gabbro. hen this was crystallized, but still at a high temperature, the alite was emplaced. This intrusion of tonalite produced a series hornblende-hybrids. The hybridization of the original gabbro endant on the injection of the tonalite is the result of a 'partial gma' of potash-felspar, quartz, and volatiles. The final intrusion granite took place while the tonalite was still incompletely crystal-d, and resulted in the formation of a zone of acid hybrid rocks. e three biotites that have been analysed occur in the granite, alite, and hornblende-hybrid respectively. The analyses were de in order to determine what changes in composition take place h an increase in the acidity of the parent rock, and whether any racteristic feature is maintained indicating their connexion as mbers within the complex.

The analyses are tabulated below and, although no striking erences of composition are shown, a number of the oxides exhibit rogressive change from the biotite of the granite to that of the alite. FeO, Al_2O_3, and Na_2O increase in the granite biotite, and O, TiO_2, and MnO decrease. The other important constituents $_2$, K_2O, and (OH,F) remain fairly constant.

. W. Chapman and C. R. Williams (2) in a study of the White ntain magma series in New Hampshire found, in passing from biotite of the gabbro to the biotite of the granite, a systematic ease in SiO_2, TiO_2, Al_2O_3, and MgO, and an increase in Fe_2O_3, , and MnO. The main difference is the opposed tendency of the

Al_2O_3 in the biotites from the two localities. But in their mos important feature, the increase of the FeO/MgO ratio, they are in ver good agreement. Correlated with this increased ratio, the refractiv indices rise in the biotites of the granites. Similarly, C. S. Hurlbut (

Analyses of biotites and their parent rocks. (Analyst, W. A. Deer.)

	I.	II.	III.	IV.	V.	VI.
SiO_2 ...	34·64	34·33	34·96	70·40	60·10	59·97
Al_2O_3 ...	16·30	14·80	15·29	14·89	16·29	16·86
Fe_2O_3 ...	3·22	2·48	2·90	0·50	1·49	1·31
FeO	19·94	19·07	18·30	1·75	3·93	4·98
MgO ...	8·23	11·62	10·42	0·83	2·83	3·20
CaO	1·03	1·56	1·11	1·61	4·85	4·52
Na_2O ...	0·80	0·65	0·41	3·88	3·92	3·89
K_2O	7·90	8·16	7·99	4·85	3·41	1·89
$H_2O+105°$ ...	2·88	2·32	3·07	0·52	1·32	0·87
$H_2O-105°$ ...	0·64	0·18	0·41	0·28	0·24	0·13
TiO_2 ...	3·48	3·63	3·99	0·68	1·17	1·21
P_2O_5 ...	nil	nil	nil	0·08	0·31	0·23
MnO ...	0·31	0·35	0·39	trace	n.d.	0·02
Li_2O ...	0·25	0·36	0·33	n.d.	n.d.	n.d.
F_2	1·69	2·38	1·17	n.d.	n.d.	n.d.
CO_2	n.d.	n.d.	n.d.	0·03	0·15	1·20
	101·31	101·89	100·74	100·30	100·01	100·28
Less O for F	0·73	1·01	0·49			
	100·58	100·88	100·25			

I, Biotite from granite. II, Biotite from tonalite. III, Biotite from ho blende-hybrid. IV, Granite. V, Tonalite. VI, Hornblende-hybrid. [The rc analyses, IV–VI, are quoted from Quart. Journ. Geol. Soc. London, 19 vol. 91, p. 72.]

The refractive indices (all ±0·002) and pleochroism of the biotites are giv below:

	I (from granite).	II (from tonalite).	III (from horn blende-hybrid
α	1·595	... 1·598	... 1·596
β	1·652	... 1·651	... 1·646
γ	1·656	... 1·652	... 1·650
$\gamma - \alpha$ ...	0·061	... 0·054	... 0·054
α	pale yellow.	... medium yellow.	... pale yellow.
β }	mottled, dark	medium yellow	yellowish-bro
γ }	yellow-brown.	brown.	medium reddi brown.

has shown that the biotites of altered gabbro xenoliths have a low FeO/MgO ratio than the biotite of the enclosing tonalite. Compari the refractive indices of the biotites of the tonalite with those the changing gabbro xenoliths, he found six out of ten had a high

efractive index than the corresponding biotite in the gabbro xenolith. he other four had the same refractive indices.

There is little doubt that the biotite compositions are closely lated to their mode of origin, as suggested by A. F. Hallimond (4, 27). The difference between the two biotites of the more basic cks and that of the granite is marked by the latter being richer in Al_2O_3 and poorer in MgO. This distinction between biotites of basic d of acid rocks has also been stated by Hallimond: 'As the content RO oxides increase in the rock the mica becomes more phlogopitic.' The variation of the Cairnsmore biotites expressed as mixtures of andard mica species displays their tendency to increase the phlogo- tic molecule as the basicity of the rock increases. The calculation based on the hexasilicate constitution of the mica suggested by allimond, and the results are tabulated below.

	Molecular proportions %					Mol. ratio RO/R_2O_3.
	Pr.	Lp.	Ph.	Pr.	Bi.	
I.	9·4	55·6	35·0	9·5	90·5	2·81
II. ...	11·0	39·0	50·0	11·0	89·0	3·65
III. ...	11·6	45·9	42·5	11·5	88·5	3·09

Pr. = Protolithionite, $2H_2O.(K,Na)_2O.Li_2O.3RO.2Al_2O_3.6SiO_2$.
Lp. = Lepidomelane, $2H_2O.(K,Na)_2O.4FeO.3(Al,Fe)_2O_3.6SiO_2$.
Ph. = Phlogopite, $2H_2O.(K,Na)_2O.6(Mg,Ca).Al_2O_3.6SiO_2$.
Bi. = Biotite species (Lp. and Ph.).

rom the above table the biotite from the hornblende-hybrid is n to be intermediate between that of the granite and the tonalite, withstanding that the hybrid is a more basic rock than the aalite, and, in fact, owes its present assemblage to the intrusion of tonalite. The biotite of the two more acid rocks has been pre- itated directly from the magma liquid, but the biotite of the rid has been formed by the destabilization of hornblende with change in the conditions of phasal equilibrium and its subsequent version to biotite. In this way it could be argued that the com- ition of the biotite arising from the hornblende depends almost irely on that of the original metasilicate. But if this was the e there is little doubt that the resulting biotite would be con- rably richer in the phlogopite molecule than the calculation ws it to be, and certainly richer than the biotite of the tonalite. intermediate position of the biotite of the hybrid is a reflection he influence of the acid 'partial magma' (1, p. 68) responsible for production of the hornblende-hybrids. In this way the phasal ilibrium is pushed beyond that of the tonalite and depends on

the potash available during the hybridization process. In a simil way the ratio RO/R_2O_3 shows the biotite of the hybrid to be t product of a condition of more acid phasal equilibrium. The Cairn more biotites confirm A. Brammall's observation that 'Increase the ratio $RO\ R_2O_3$ implies, in general, retrogression towards the fie of the basic rocks' (5, p. 185).

Number of metal atoms on basis of 12(O,OH,F) in analysed biotites (I–III).

	I.			II.			III.		
	Mol. prop.	Metal atoms.		Mol. prop.	Metal atoms.		Mol. prop.	Metal atoms.	
SiO_2 ...	0·5745	2·663	4·00	0·5693	2·631	3·98	0·5798	2·672	4·0
Al_2O_3 ...	0·1595	1·478		0·1448	1·344		0·1496	1·379	
Li_2O ...	0·0084	0·083		0·0120	0·111		0·0110	0·101	
TiO_2 ...	0·0434	0·201		0·0453	0·209		0·0498	0·230	
Fe_2O_3 ...	0·0202	0·187		0·0155	0·143	3·04	0·0182	0·168	
FeO ...	0·2775	1·286	2·86	0·2654	1·227		0·2547	1·173	2·0
MnO ...	0·0044	0·020		0·0049	0·023		0·0055	0·025	
MgO ...	0·2041	0·946		0·2882	1·332		0·2584	1·191	
CaO ...	0·0184	0·085		0·0278	0·128		0·0198	0·091	
Na_2O ...	0·0129	0·120	0·98	0·0105	0·097	1·02	0·0066	0·061	0·
K_2O ...	0·0839	0·778		0·0866	0·800		0·0847	0·781	
H_2O+ ...	0·1599	1·483	1·90	0·1288	1·191	1·78	0·1704	1·570	1·
F_2 ...	0·0450	0·417		0·0620	0·586		0·0310	0·286	

I. $(OH,F)_{1·9}(Mg,Fe'',Fe''',Ti,Li,Mn,Al)_{2·9}[(Si,Al)_4O_{10}](K,Na,Ca)_{1·0}$.
II. $(OH,F)_{1·8}(Mg,Fe'',Fe''',Ti,Li,Mn)_3[(Si,Al)_4O_{10}](K,Na,Ca)_{1·0}$.
III. $(OH,F)_{1·9}(Mg,Fe'',F''',Ti,Li,Mn,Al)_{2·9}[(Si,Al)_4O_{10}](K,Na,Ca)_{0·9}$.

The complete structure of biotite has not yet been determin by X-ray analysis, but the partial analyses of L. Pauling (6) a C. Mauguin (7), together with the work of W. W. Jackson and J. West (on the structure of muscovite, J. W. Gruner (9) on the structure of ta and pyrophyllite, and R. C. McMurchy (10) on the structure of chlori along with the chemical study on the brittle micas by G. Koch (1 leaves little doubt that the biotite formula[1] can be written stru turally as $KX_nY_4O_{10}(OH,F)_2$, in which X represents cations of c ordination number 6, and Y cations of co-ordination number 4, wi $2 \leqslant n \geqslant 3$.

This formula, written so as to cover the usual replacements with the various groups, becomes

$$(OH,F)_2(K,Na,Ca).(Mg,Fe'',Fe''',Ti,Al,Li,Mn)_{2-3}[(Si,Al)_4O_{10}].$$

[1] This formula, $(OH,F)_2KX_nY_4O_{10}$, given by Pauling, must not be confus with Machatschki's formula (12) $(OH,F)_2WY_3[z_4O_{10}]$, in which z = cations wi ionic radius $0·4 \pm 0·1$ Å. (Si,Al); Y = cations with ionic radius $0·75 \pm 0·15$ (Fe'',Fe''',Al,Ti,Mn,Li); W = cations with ionic radius $1·3 \pm 0·1$ Å. (K).

our molecules, each containing twelve oxygen atoms, are present the unit cell. Two of these oxygen atoms belong to (OH) groups nd are replaceable by fluorine so that in fluorine-bearing biotites he value of O + F is twelve.

The three biotites from Cairnsmore have been calculated on the sis of twelve oxygen atoms in the unit cell, in order to compare em with the above structural formula. These are given on p. 498 gether with the corresponding formulae.

Similar formulae for five biotites from the Dartmoor granites, duced from the analyses given by Brammall and Harwood (5), are follows:

1. $(OH,F)_{1\cdot9}(Mg,Fe'',Fe''',Ti,Mn,Li,Al)_{2\cdot7}[(Si,Al)_4O_{10}](K,Na,Ca)_{0\cdot9}$
2. $(OH,F)_{2\cdot5}(Mg,Fe'',Fe''',Ti,Mn,Li,Al)_{2\cdot6}[(Si,Al)_4O_{10}](K,Na,Ca)_{0\cdot9}$
3. $(OH,F)_{2\cdot2}(Mg,Fe'',Fe''',Ti,Mn,Li,Al)_{2\cdot7}[(Si,Al)_4O_{10}](K,Na,Ca)_{0\cdot9}$
4. $(OH,F)_{1\cdot6}(Mg,Fe'',Fe''',Ti,Mn,Li,Al)_{2\cdot9}[(Si,Al)_4O_{10}](K,Na,Ca)_{1\cdot0}$
5. $(OH,F)_2(Mg,Fe'',Fe''',Ti,Mn,Li,Al)_{2\cdot7}[(Si,Al)_4O_{10}](K,Na,Ca)_{1\cdot0}$

It will be seen that these analyses agree well with the structural mula, and also give some indication of the structural range of tite. C. Mauguin (7, p. 881) has stated that the number of the group with co-ordination number 6 (Mg, &c.) in biotites is 3, and t the number of metal plus silicon atoms is 8. 'In margarite muscovite the total number of metal and silicon atoms is 7, in dolite, phlogopite, and biotite it is 8.' L. Pauling (6, p. 128) gested, as indicated in the structural formula, that the value of X group can vary within the limits 2–3. This second suggestion een to be the more correct from the above analyses, in which the ue for the X group varies from 2·6 to 3, and the total number of tal and silicon atoms varies between 7·5 and 8. Whether this X up value can vary between the minimum 2 and 3 in a complete ge seems unlikely, but any value between $n = 2\cdot5$ and 3 is pos- le. The increase in the value of the X group towards 3 indicates increase in the phlogopite molecule of the biotite [see table of lyses].

From the above formulae some of the other points suggested by Pauling are confirmed. Within the limited variation of the lime tent of the biotites, Ca^{++} can replace K^+ as well as Na^+. This already been suggested by A. N. Winchell (13) from a purely mical study. Nor is it surprising, as the structural layers in the tle micas are held together by Ca^{++} ions instead of K^+ ions. ther, it is well known that calcium can replace sodium and assium in the amphibole structure (14). In calculating the formulae,

Mn^{++} has been placed in the X group according to W. Vernadsky (1 and others, but in virtue of its intermediate ionic radius between th X group and the (K,Na,Ca) group it may be able to enter into th second group in those biotites which are below the unity value (e. Cairnsmore, anal. no. III; Dartmoor, anal. nos. 1, 2, 3). Li^{+}, suggested by its ionic radius, replaces Mg^{++} in the X group. Th becomes obvious in the case of the lithium-micas, lepidolite an zinnwaldite.

In the Cairnsmore biotites the amount of aluminium replacin silicon is nearly constant and has an average of 1·34 in the Y_4 grou Those from the Dartmoor intrusion are rather less constant and ha an average of 1·32. These values indicate a close approximation a 1 : 2 replacement of silicon by aluminium within the tetrahedr groups in biotite of granites and intermediate rocks.

The constant deficiency of the (OH,F) group below the value 2 the analyses of the Cairnsmore biotites is probably due to the dif culty of the accurate determination of fluorine. W. Kunitz (16) h suggested that some of the water may have been reduced by F during the ignition giving a somewhat low value for H_2O (+105 This effect is too small, however, to account for the observed differenc of the analytical and structural value in some cases (e.g. Dartmo no. 4). This discrepancy in the value of H_2O (+F) has been not by Winchell (17) in calculating many recent analyses.

The structural formulae show the essential similarity of the thr Cairnsmore biotites and distinguish them from those of the Dartmo biotites. The distinction of the biotites from acid and intermedia rocks is shown by the position of the aluminium in the structu In the acid rocks part of the aluminium replaces magnesium, in t intermediate the whole is replacing silicon.[1]

In conclusion, the following points are emphasized:

(1) The biotite FeO/MgO ratio is progressively increased as t rock becomes more acid; i.e. the micas change away from phlogopi towards an iron-rich lepidomelane.

[1] The biotites from the White Mountain magma series (Chapman and Willian 1935, p. 512) do not conform with this suggestion. In each of the biotites fr the granite, monzodiorite, and gabbro, part of the aluminium is replacing m nesium. The two latter analyses, however, do not fit the structural formula biotite.

1. $(OH,F)_{1\cdot6}(Mg,Fe'',Fe''',Ti,Mn,Al)_3[(Si,Al)_4O_{10}](K,Na,Ca)_{0\cdot9}$.
2. $(OH,F)_{0\cdot8}(Mg,Fe'',Fe''',Ti,Mn,Al)_{3\cdot3}[(Si,Al)_4O_{10}](K,Na,Ca)_{1\cdot0}$.
3. $(OH,F)_{0\cdot8}(Mg,Fe'',Ti,Mn,Al)_{3\cdot3}[(Si,Al)_4O_{10}](K,Na,Ca)_{0\cdot9}$.

(2) The ratio RO/R_2O_3 increases in the biotites of the more basic rocks.

(3) Aluminium replaces magnesium in the Y group, as well as silicon in the tetrahedra, in the biotites of the more acid rocks.

(4) There is a close relationship between the biotite and the rock in which it occurs when the mineral has been precipitated directly from a magma liquid. This relationship does not apparently hold when the assemblage is the result of hybridization unless equilibrium has been established.

(5) The biotites of the complex show a characteristic similarity and differ from those of other intrusions, for example, the Dartmoor complex and the White Mountain magma series.

The author is indebted to Professor C. E. Tilley for reading and criticizing the manuscript.

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[M.A. 6–294.]

The tektite problem.[1]

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[Read January 28, 1937.]

THE natural glasses, found as small corroded pieces scattered on the earth's surface and in alluvial deposits in a few limited areas, have long presented a puzzling problem; and many theories have been propounded to explain their origin. They have been known in Southern Bohemia and western Moravia since before 1787; and similar material has since been found in the Dutch East Indies, Malay States, Australia, Tasmania, French Indo-China, south China, Philippine Islands, and quite recently in the Ivory Coast in West Africa [M.A. **6**–106]. These glasses are distinct in chemical composition from volcanic glass (obsidian), and there are no volcanoes in the districts where they are found. They have been given the names moldavites, billitonites, australites, Darwin glass, indochinites, rizalites [M.A. **4**–422; **6**–403], &c.

In 1900, Professor F. E. Suess of Vienna included all these under the term tektites, and he put forward the theory that they are of meteoritic origin. This theory has found general acceptance, but as a matter of fact there is no direct evidence for its support. None of the glasses has been seen to fall from the sky; and they are quite different in chemical composition and structure from any meteorite (aerite or stone) actually observed to fall. Differing from all known terrestrial materials (except those quite recently recognized as ound meteorite craters) and being found under strange circumstances, it is perhaps natural to assume that they have simply fallen from the sky. Professor Suess's main argument that they are of cosmic origin was based on a certain similarity in the surface sculp-

[1] Read by Prof. L. F. Brady at the Fourth Annual Meeting of the Society for Research on Meteorites, University of California at Los Angeles, June 23 and 24, 1936. Reprinted from Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 381–383. References to Mineralogical Abstracts [M.A.] and the Mineralogical Magazine have been inserted in this reprint.

turing to that seen on meteoritic stones; and he assumed that tl was produced by friction and corrosion in the earth's atmosphe But similar surfaces are shown by weathered rocks (especially lim stone), and it is now generally admitted that the peculiar types sculpturing shown by tektites are due to chemical corrosion by hum acids in the soil [M.A. **3**–98; **5**–303; **6**–18, 107].

The peculiar forms of australites ('blackfellows' buttons') cann however, be explained in this way. These were produced no dou by the spinning of a viscous mass [M.A. **6**–18]. It has therefo been assumed that the glass was melted by the heat developed friction in the earth's atmosphere. It is well known that the surfa of meteorites is fused during their rapid passage through the atm sphere. But it is evident that this fused material must be wiped (ablated) as quickly as it is formed, so producing the fiery trail fireballs. When meteorites reach the ground they are seen to covered with a thin skin of glassy material (the fused crust), whi rarely exceeds a millimetre in thickness. It is evident that mete ites that reach the ground are only a fraction of their size when th entered the earth's atmosphere; and it is only really big ones th have a chance of getting through. A blob of molten material trav ling at a high velocity would not hold together. Rain does n come down in lumps.

The suggestion was made by H. Michel in 1925 [M.A. **3**–97], a more recently supported by A. Lacroix [M.A. **5**–303] and F. E. Su [M.A. **6**–108], that tektites have been formed in a molten conditi in the earth's atmosphere by the burning of meteoritic masses of t element silicon (Si) with some metallic aluminium, calcium, potassiu &c. But such a burning would surely cause the dispersal of t matter in a fiery trail.

Further, as recently pointed out by Fletcher Watson, Jr., a letter to 'Nature' (London, 1935, vol. 136, p. 105) [M.A. **6**–20 time is required for the conduction of heat into a solid body. Ev with the higher degree of conductivity of siderites, the heating zo shown by the transformation of α-iron to γ-iron (which takes place a temperature of 850° C.), extends to a depth of only a few mi metres [Min. Mag. **24**–17]. This fact indicates that the molt material is wiped off the surface in the rush of air as quickly as h is conducted into the interior of the mass. Meteoritic stones a show only a very slight heating effect beyond the fused glassy cru

It is thus clearly impossible that tektites could have been co

etely fused during their brief flight through the earth's atmosphere.
r. Charles Fenner has recently (1935) [M.A. **6**–208] suggested that
e peculiar button shape of australites has been formed by ablation
m a sphere of solid glass entering the atmosphere.

Tektites contain from 70 % to 80 % of silica and are an impure
rm of silica-glass. In recent years the presence of silica-glass in
rge quantities has been recognized around the undoubted meteorite
nters at Canyon Diablo in Arizona [M.A. **5**–16], Wabar in Arabia,
d Henbury in Central Australia [Min. Mag. **23**–387]. It has here
en formed by the melting of sandstone or desert sand in the
nse heat generated by the impact of a really large mass of
teoritic iron. The air resistance is proportional to the square of
e radius of the body, while the momentum is proportional to the
be of the radius. Hence a large mass will reach the earth's surface
th a greater velocity. The kinetic energy, measured by $\frac{1}{2}mv^2$,
ll be suddenly transformed into heat, giving rise to a violent
seous explosion and the formation of a crater [M.A. **5**–301]. The
terial from Wabar affords ample evidence of extremely high
mperatures. The molten silica not only boiled, but was vaporized;
the meteoritic iron also was vaporized and came down again as
ine rain [Min. Mag. **23**–399].

The Darwin glass from Tasmania, which has been classed with the
tites, compares exactly in its form and chemical composition with
silica-glass from Wabar [M.A. **6**–106, 407]. It covers a wide
a in glacial deposits, but no trace of meteoritic iron or of
eorite craters has been found there. However, the iron would
n be destroyed by weathering, and the craters obliterated by
cial action and denudation. Silica-glass is very resistant to
mical action, and also, on account of its very low coefficient of
rmal expansion, it is not broken by changes of temperature. It
refore has remained to tell the tale.

This meteorite-crater theory of the origin of tektites, which I first
anced in 1933 (Nature, London, vol. 131, p. 117; Compt. Rend.
d. Sci. Paris, vol. 196, p. 710) [M.A. **5**–304], has been criticized
A. **6**–407] on the ground that tektites are found over a much
er area than that occupied by meteorite craters, and that they
not always found in the neighbourhood of the right kind of rocks
yield such a fused product. The local distribution of tektites
st, however, be considered in connexion with not only recent but
ancient systems of drainage, and perhaps also (as in Tasmania)

with glacial action. And further, it must be remembered that silic glass is a material that will survive for a long period. But I mu admit that the peculiar forms and the very wide distribution australites present a difficulty. Still we have for this theory son scraps of positive evidence, whereas the meteoritic theory is bas only on negative evidence.

Closely allied to tektites, and no doubt to be classed with the are the lumps (of weights up to 16 pounds) of almost pure silic glass (SiO_2 97½ %) recently found in the Sand Sea of the Liby Desert [Min. Mag. **23**–501]. This material is clear, with a yellowis green colour, and is suitable for cutting as gemstones. It present such a strange problem that I was glad to have the privilege joining a special expedition of the Survey of Egypt to investiga the matter in December, 1934. The glass was found sparing scattered over an area of 85 by 35 miles with the largest amount our Camp 7, lat. 25° 17′ 54″ N., long. 25° 34′ 0″ E. Unfortunate we were not able to trace the material to any source, and no trace meteorites or of meteorite craters could be found amongst high san dunes. It seemed easier to assume that it had simply fallen fr the sky! But the problem still remains unsolved.

MINERALOGICAL ABSTRACTS

(Vol. 6, No. 9, March, 1937.)

Notices of Books.

EAD (H. H.). *Rutley's Elements of mineralogy.* 23rd edition, London (Thomas Murby & Co.), 1936, viii + 490 pp., 128 figs. Price 8*s*.

This volume is very different from the small 'Rutley' which, as y first book on mineralogy, I bought in 1887 for eighteen pence. he first edition by Frank Rutley [1842–1904] appeared in 1874, nd a considerable revision and enlargement was made by H. H. ead for the 19th edition in 1915 [but dated 1916 on the title-page; .A. **1**–116]. Subsequent editions showed the same number of pages .A. **1**–180; **4**–146]. The present 23rd edition shows another enlarge- nt both in size (100 more pages and on thicker paper) and price. he text has been largely rewritten and a new chapter added on 'The currence of minerals'. Many new figures have been added and the ld ones redrawn (except the freehand sketches of mineral specimens, me of which are poor). In the descriptive portion a new chemical d economic classification has been devised, and interesting notes e added on the uses of the various minerals. The result is an tirely new and excellent text-book. L. J. S.

ASZKIEWICZ (Antoni). *Mineralogia.* Biblioteka 'Wiadomości far- maceutycznych', vol. 28, Warszawa (Fr. Herod), 1936, xii + 204 pp., 4 pls., 187 text-figs. Price 10zł.

In this elementary text-book, written in Polish, the general part 52 pages gives prominence to the structure of crystals as deter- ned by X-ray methods. The descriptive part deals with all the mmon minerals, giving good figures of crystals and mention of eir more important localities in Poland. This is followed by a short apter on rocks and meteorites and lists of minerals under chemical ements and uses. The phonetic spelling of mineral names produces ne strange disguises. [M.A. **4**–339; M.M. **21**–472.] L. J. S.

AVÍK (František). *Úvod do speciální mineralogie.* [Introduction to special mineralogy.] Praha (Melantrich), 1936, 114 pp., 17 figs.

An introduction to the study of systematic mineralogy, with apters on the historical evolution of mineral systems; principal

facts of mineral chemistry, forming a basis of the system (isomorphisı colloids and metacolloids, water in minerals, homogeneity); chemic formulae and their interpretation; nomenclature; geochemistry elements and of groups of minerals; synopsis of the chemical syste The silicates are grouped in two parallel series of anhydrides a hydrates. F. S.

Buttgenbach (H.). *Cours d'optique cristalline.* Paris (Dunod) Liége (Vaillant-Carmanne), 1936, 176 pp., 125 figs. Pri 20 belgas.

This is an extension of the optical chapter (63 pages) in t author's 'Les minéraux et les roches' [M.A. **6**–194]. In 227 number paragraphs the principles of the geometrical optics of crystals a worked out and concisely stated, and details are given of the metho for the determination of optical data. L. J. S.

Thompson (R. Campbell). *A dictionary of Assyrian chemistry a geology.* Oxford (Clarendon Press), 1936, xlviii + 266 pp. Pri 21*s*. [Cf. M.A. **6**–245.]

With much ingenuity the author has puzzled out the names a significance of mineral substances recorded in the cuneiform inscri tions of a dead and forgotten language found on clay tablets dati from before the fall of Nineveh in 612 B.C. The 'Dictionary' tak the form of detailed discussions of the possible meanings of the nam and the uses of the materials, grouped under the headings: sal earths, arsenic group, metals, red stones, blue stones, marb alabaster, gypsum, plaster, materials for glass making, stones f carving and building, &c. The 'Geology' is limited to some accou of these materials. The text is written in an obscure and diffic style, and is littered throughout with abbreviations of various kin the meanings of which are almost as difficult to decipher as t original inscriptions themselves. For example, under the headi 'Assyrian geological methods':

The word IA_4(*TÀK*), *abnu*, lit. 'stone', is used as a determinative to m forms of minerals (see Jastrow, *PRSM.* 1914, 153: *OTC.* 2),

and under Gold; *Ḫuraṣu*, *GUŠKIN*:

Gold was found in Aralu (perhaps intended for humour, 'Hades, the Und world', ii *R.* 51, i–ii, 11: cf. *ḫuraṣu binut ZU.AB*, *KAH.* 75, 25: and see 5 (*ṣariru*): gold dust was brought from Ḫaḫu (Gudea, *ISA.* 111, 33, according Sidney Smith, *EHA.* 99, it = Cilicia).

Several of these signs are the bibliographical references, a lo list of which is given, including *EM*, *AKSAW*, *MAOG*, *MDA(O)*

M (i.e. F. Rutley, Elements of Mineralogy, &c.), usually without ny mention of date or edition. Nevertheless, with a little patience, uch interesting and curious information, especially regarding the edicinal uses of minerals, may be gathered from the book. But it unfortunate that, in the lengthy introduction, the Assyrian scholar d not have more in mind the less-learned chemist and mineralogist terested in the history of science. There are fifteen separate indexes various languages. L. J. S.

Meteorites and Tektites.

ntributions from the Society for Research on Meteorites. Edited by Frederick C. Leonard and H. H. Nininger. 1936, fascicle no. 1 (for 1935), 45 pp., 2 figs.

Collected reprints of articles and notes that appeared under this ading in 'Popular Astronomy', 1935, vol. 43 [M.A. **6**–99–105, 98]. L. J. S.

NINGER (Harvey H.). *Proposed national institute of meteoritical research.* Pan-Amer. Geol., 1935, vol. 64, pp. 107–124.

The following programme of co-operative work is suggested. Fireball, luminous train, and dust-cloud survey. 2, Field search meteorites of unwitnessed falls. 3, Chemical, petrographical, and tallographical research. 4, Aerial surveys for meteorite craters. Reconnaissance and exploration of meteorite craters. 6, Explora- n of submarine oozes for meteoritic material. 7, Exploration of tic snows for meteoritic material. 8, Publication of a journal of teoritical research. L. J. S.

NINGER (H. H.). *Terminology of meteoritics.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 194–203.

Various inconsistencies in the use of the terms meteor, fireball, lide, meteorite, meteoroid, &c., are noted. L. J. S.

TTGENBACH (H.). *Les météorites.* Bull. Cl. Sci. Acad. Roy. Belgique, 1935, ser. 5, vol. 21, pp. 1119–1137.

A general review of the subject. L. J. S.

CHATSCHKI (F.). *Die mineralogisch-petrographischen Sammlungen der Universität Tübingen.* Undated [1936 ?], 4 pp.

This popular leaflet gives a brief account of the meteorite collec- n in the University of Tübingen, which after that in Berlin is the st complete collection in Germany, containing about 300 falls with

a total weight of about 300 kg. There are large masses of the siderit Carthage, Tennessee (64 kg.), Magura, Slovakia (46 kg.), and Lin Creek, Alabama (40 kg.). The larger part of the collection was giv by Baron K. L. von Reichenbach (1788–1869). L. J. S.

Borgström (L.). *Meteoritstatistik.* Årsbok—Vuosikirja Soc. S Fennica, Helsingfors, 1934, vol. 12, pt. B, no. 7, 18 pp., 7 fig

A lecture in Swedish giving some historical details. During t years 1820–1910 the recorded number of falls of meteorites a 27 siderites with a total weight of 3500 kg. and 502 stones witl total weight of about 8000 kg., the mean specific gravity being abo 4·0. Tables and curves are given of the numbers of falls by the ho and by the month in different latitudes on the earth's surface. [Min. Mag. **23**–291.] L. J. S.

Borgström (L. H.). *Meteoriternas härkomst och deras kemi.* [Ori and chemistry of meteorites.] Nordiska (19. Skandinavisl naturforskarmötet i Helsingfors, 1936, separate 2 pp.

Meteorites are compared with the materials of the earth's interi L. J. S

Wylie (C. C.) & Naiden (J. R.). *The image that fell down fr Jupiter.* Popular Astronomy, Northfield, Minnesota, 19 vol. 44, pp. 514–520, 1 fig.

It is argued that the image (*Διοπετής*) mentioned in Acts (xix, was a carved wooden image, and not a meteorite as often suppos [Cf. M.A. **5**–151.] L. J. S

Wylie (C. C.). *The Lord cast down great stones from heaven.* Popu Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 378–3 1 fig.

The man-killing 'hailstones' mentioned in the Book of Josl (x, 11) have been considered by some authors to be perhaps met rites. But hailstones up to 6 inches across are known; and m fatalities have been caused by these, though none on record meteorites. L. J. S

Wylie (C. C.). *The resistance of the air to meteors.* Popu Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 281–2

An equation is deduced. L. J. S

LIE (C. C.). *Rate of fall of meteoric material on the earth.* Physical Rev., 1935, vol. 47, p. 192.

The amount is estimated at 10 grams per square mile per annum. [M.A. **6**–100.] L. J. S.

NINGER (H. H.). *Why is a meteor?* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 383–388, 4 figs.

The persistent luminous cloud at a height of 30–50 miles formed the fireball of March 24, 1933 [M.A. **6**–105] is estimated to have a length of 200 miles and a volume of 1000 cubic miles. The minous sphere of the fireball is estimated at 6 miles in diameter, the trail one mile across. With velocities greater than that of nd the air resistance increases at a much more rapid rate than the are of the velocity; and it is evident that much material must be orized during the early stages of flight of a meteor through the th's atmosphere. L. J. S.

INGER (H. H.). *Further studies in the surface features of meteorites.* Amer. Journ. Sci., 1936, ser. 5, vol. 32, pp. 1–20, 8 figs. Correction, p. 315. [Cf. M.A. **6**–100.]

study of 4320 meteoric stones, mostly from showers, shows that y 5·4 % are oriented. In the case of falls represented by a single 13 % are oriented. A higher percentage (37 %) is found in fore- falls (these had an added relative velocity in meeting the earth). he few unweathered siderites orientation was seen in 28 % (the er percentage being here due to the less frequent breaking up of mass during flight). In oriented meteorites the front surface is e often spheroidal than conical, the former representing a more ure stage of shaping. Surface pitting appears to have taken place ing the last stages of the luminous flight, when with a lower temature there may have been a differential fusion of the constituents. L. J. S.

INGER (H. H.). *Directions for the etching and preservation of metallic meteorites.* Proc. Colorado Mus. Nat. Hist., 1936, vol. 15, no. 1, 8 pp., 4 pls.

he finely ground or polished slices to be etched are first coated he edges and back with shellac, all fissures are filled, and nodules roilite covered. The etching is done in a 6 % solution of nitric for two to five minutes. If troilite is finely disseminated, staining be partly avoided by using a 5½ % solution of nitric acid in alcohol.

Finally the etched surface is lacquered. Changes of temperature caus by a part-time exposure to direct sunlight may cause a deteriorati of the specimens. L. J. S.

Nininger (H. H.). *Depth of meteorites and gradation of the gr plains.* Journ. Geol. Chicago, 1936, vol. 44, pp. 66–67.

A much weathered meteoric stone weighing 749 lb. was found [d not stated] when ploughing near Hugoton, Stevens Co., Kansas. base was only 36 inches beneath the surface of the ground. Compar with the depths to which meteorites seen to fall have penetrated, tl suggests that the surface of the ground has suffered eolian degrad tion. In a postscript footnote, mention is made of the recent find a stone of 623 lb. at a depth of 20 inches in Graham Co., Kansas. L. J. S.

Schwarz (M. *v.*) & Baur (H.). *Feingefügeuntersuchungen von Mete eisen.* Zentr. Min., Abt. A, 1936, pp. 207–218, 15 figs.

Photomicrographs (× 5–200) of various siderites and sideroli are figured and described. Henbury (Central Australia) shows c formed bands of taenite and granular kamacite, due to shock a heating at the time of fall. 'Hiquipilco' [i.e. Xiquipilco = Tolu shows rhabdite needles traversing grains of recrystallized kamaci and also traces of octahedral structure. Mocs (Transylvania) sho recrystallization of kamacite along Neumann lines. Staunton (V ginia), Putnam Co. (Georgia), and Cincinnati (Ohio) also show so recrystallization. The pallasite of 'Atacama' [= Imilac] and t mesosiderite of 'Mejillones' [= Vaca Muerta] are also figured. L. J. S.

Buddhue (John Davis). *Relationships between the structure and compositions of iron meteorites.* Popular Astronomy, Northfie Minnesota, 1936, vol. 44, pp. 511–514.

Nickel shows a gradual increase from 4·99 % in hexahedrites 6·00 % in the coarsest octahedrites and 8·24 % in the finest oct hedrites. Kamacite has the composition $Fe_{14}Ni$. Analyses of taeni range from Fe_7Ni to FeNi, the majority being between Fe_3Ni a Fe_2Ni. The iron-nickel diagram suggests a compound Fe_2Ni; this called 'orthotaenite', while other material ('metataenite') no dou contains admixed kamacite. The Widmanstetter structure of oct hedrites arises from the cooling of a homogeneous solid soluti of the face-centred cubic γ-phase, with the separation of kamaci

ody-centred cubic α-phase), the (110) planes of the latter being rallel to the (111) of the former [M.A. **3**–259; M.M. **22**–382]. The enite border is formed by the diffusion of nickel, since kamacite ntains less nickel than the original solid solution. The greater the nount of nickel, the more quickly is the taenite border formed, nce producing a finer structure. Hexahedrites may be regarded octahedrites with very wide kamacite bands. Ataxites may be tahedrites that have been granulated by extreme or prolonged ating, or alloys with too little or too much nickel to favour the rmation of the Widmanstetter structure. L. J. S.

PMAN (Charles B.). *Bacteria in meteorites.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 442–446.
A reply to S. K. Roy [M.A. **6**–204]. L. J. S.

ODACK (Ida). *Die Häufigkeiten der seltenen Erden in Meteoriten.* Zeits. Anorg. Chem., 1935, vol. 225, pp. 337–364, 2 figs.
Fragments from eight and fourteen different meteoric stones in two s (143·3 and 186·5 grams respectively), and from seven meteoric ns (650 grams), were extracted chemically and examined by X-ray ctroscopy for the following rare-earth elements Sc, Y, La, Ce, Pr, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tu Yb, Cp. The relative amounts each of these are stated; scandium and yttrium predominate. ir total amount is $3{\cdot}229 \times 10^{-5}$ by weight (or $7{\cdot}328 \times 10^{-6}$ by ms) of the whole. In the meteoric irons the concentration is about of this amount. L. J. S.

GG (Arthur S.). *An examination of the spectra of three meteorites.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 282–283.
The carbon-arc spectrum of the Canyon Diablo (Arizona) siderite wed Fe, Ni, Co, Cu, and small amounts of Ca, Pb, Ag, Ga, Ge, Na, Mg, Si, Al, Zn, Sn, P, and Mo; Pt and diamond not detected. Staunton (Virginia) siderite showed a much smaller variety of ments. The Allegan (Michigan) stone showed, besides Fe, Ni, Co, gh content of Na, Mg, Cr, Mn, Ca, and smaller amounts of Li, Al, *sic*], Pb, Cu, K, Ti, V, Mo (?), Pd (?). L. J. S.

G (Arthur S.). *The spectra of meteorites.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 507–511.
rc spectra of a number of irons and stones showed the presence both of Li, Na, Mg, Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni,

Cu, Zn, Ga, Ge, Sr, Ag, Ba, Pb; in the irons also Mo, Ru, Sn, Sb, Au and in stones Sc, Rb, Cs. Gallium and germanium were found in relatively large amounts, especially in the irons. Graphite from the Elden meteorite [M.A. **5**–157] showed lines of CN and ionized carbon and the isotopes C^{12} and C^{13} are in the same relative abundance as in terrestrial graphite. L. J. S.

Dorronsoro (J.) & Moreno Martín (F.). *Sobre un hierro meteórico de la provincia de Granada.* Anal. Soc. Española Fís. Quím. 1934, vol. 32, pp. 1111–1115, 4 figs.

A pitted mass of iron, $52 \times 42 \times 16$ cm. weighing 134 kg. was found in 1912 at a depth of one metre at Colomera. Sp. gr. 7·29–7·38. Analysis gave Fe (diff.) 91·500, Ni 7·162, Co 0·426, S 0·12, C 0·112, P 0·028, SiO_2 0·645. Spectographic analysis shows the presence also of Ge, Mg, Ag. An etched surface shows Neumann lines, but no Widmanstetter figures. L. J. S.

Schadler (Josef) & Rosenhagen (Justus). *Auffindung des Meteorsteins und Maßnahmen zur wissenschaftlichen Untersuchung.* Jahresber. Oberösterr. Musealvereins, Linz, 1935, vol. 86, pp. 102–164, 8 pls., 16 text-figs.

——— *Ein bemerkenswerter Meteorsteinfall in Oberösterreich.* Forsch. u. Fortschr., 1936, vol. 12, p. 53. [Abstract of the preceding paper.]

A detailed account of previous work with further enlarged photographs of the Prambachkirchen meteorite [M.A. **6**–11]. The phenomena attending the path of the meteorite and its collision with the earth's surface are more fully discussed. F. A. B.

Želízko (Josef V.). *Přehled minerálů jižních Čech.* [Synopsis of minerals of southern Bohemia.] Vodňany, Bohemia, 1936, 13 pp.

Besides giving a compilation of published data on the minerals of southern Bohemia, the author quotes an old document which suggests that the Bohumilice (Bohumilitz) meteoric iron, found in 1829 and 1925 [M.A. **6**–12], may have fallen on January 1, 1770. F. S.

[Chirvinsky (P. N.)] Чирвинский (П. Н.). Эвкрит 8/9 февраля 1929 г. из Падварнинкай в Литве.—Tschirwinski (P. N.). *Evkrit* [i.e. Eukrit] *aus Padvarninkai in Litauen (8/9 Februar 1929).* Зап. Всеросс. Мин. Общ. (Mém. Soc. Russe Min.), 1935, ser. 2, vol. 64, pp. 328–343 (Russ.), 343–346 (Germ.), 1 pl.

Micrometric measurements of thin sections of two stones of the shower at Padvarninkai, Lithuania [M.A. **4**–419, 420] gave mon

nic pyroxene 87·02 (70·70), maskelynite 11·41 (26·80), metallic n 0·14 (2·20), pyrrhotine 0·99 (nil), magnetite 0·44 (0·30) volume %. om these figures detailed chemical analyses are calculated to two aces of decimals. L. J. S.

RINOV (E. L.)] Кринов (Е. Л.). Метеорит из Старого Борискина. —Krinov (E.). *Le météorite de Staroje Boriskino.* Докл. Акад. Наук СССР (Compt. Rend. Acad. Sci. URSS), 1931, pp. 262–268, 3 figs.

— Еще о метеорите Борискино. (*Encore sur la météorite de Boriskino*). Труд. Ломоносов. Инст. Акад. Наук СССР (Trav. Inst. Lomonossoff, Acad. Sci. URSS), 1933, no. 2, pp. 69–71 (Russ.), 1 pl. (map).

After the appearance of a fireball with two or three detonations, meteoric shower fell on April 20, 1930, at Staroe Boriskino 14′ N., 52° 29′ E.), a village situated between Bugulma and guruslan, govt. Samara. Two stones, found 2 km. apart and ghing 1165·6 grams, were recovered; three others are said to e been accidentally destroyed. No description of the material given, beyond the statement that it falls to pieces in water and its a nasty smell. S. I. T.

LSON (A. L.). *Meteorites.* Trans. Mining Geol. Inst. India, 1936, vol. 30, pp. 143–158, 5 pls.

A general account with discussion on the origin of meteorites. ores are given of the following new Indian meteorites: Bahjoi, adabad district (iron, fell July 23, 1934) [M.A. **6**–102, 394], peti, and Patwar [M.A. **6**–206]. L. J. S.

LSON (A. L.). *The Patwar meteoric shower of the 29th July, 1935.* Rec. Geol. Surv. India, 1936, vol. 69, pp. 439–457, 8 pls., 1 text-fig.

urther details are now given of this meteorite [M.A. **6**–206]. is classed as a mesosiderite (grahamite) with a predominating ount of nickel-iron, though this does not form a continuous net- k. Embedded in the metallic groundmass are large (up to $< 1\frac{1}{2}$ inches) granular masses of olivine and bytownite, crystals of ine, enstatite (α 1·657, β 1·662, γ 1·669) with some monoclinic oxene (perhaps pigeonite), small patches of felspar (bytownite, 573, $\gamma < 1{\cdot}578$), and smaller amounts of schreibersite, troilite,

oldhamite (detected by the presence of calcium when the powder material was boiled in water), lawrencite, and a hydrocarbon (d tected by heating in a bulb-tube). The olivine has α 1·682, sp. g 3·55; analysis by P. C. Roy of lighter coloured material ga SiO_2 40·26, FeO 9·84, MgO 49·33 = 99·43. L. J. S.

Coulson (A. L.). *The Perpeti meteoric shower of the 14th Ma 1935.* Rec. Geol. Surv. India, 1936, vol. 71, pp. 123–143, pls., 1 text-fig.

The weight of the largest stone [M.A. **6**–206] is 6869·85 grams [r 6689·85]. One stone shows a secondary crust on two surfaces. Th sections show nickel-iron, troilite, magnetite, chromite, olivi clinoenstatite, enstatite, apatite ?, oligoclase, and glass. Analy by E. Spencer and K. B. Sen give the bulk composition Fe 7·(Ni 1·18, Co 0·05 (nickel-iron 8·24, Fe : Ni = 6 : 1), Fe 3·88, S 2· (troilite 6·10), Ca 0·08, S 0·06 (oldhamite 0·14), SiO_2 39·09, Ti 0·16, Al_2O_3 1·35, Cr_2O_3 0·65, Fe_2O_3 4·21, FeO 11·19, MnO 0·(MgO 25·11, CaO 1·88, Na_2O 1·17, K_2O 0·14, P_2O_5 0·27, correspondi to olivine 31·90 (MgO : FeO = 3 : 1), pyroxene 37·01, felspar 6·(magnetite 6·12, chromite 0·96, ilmenite 0·30, apatite 1·33. T meteorite is an enstatite-olivine-chondrite of the Baroti type.

L. J. S.

Krishnan (M. S.). *The Tirupati and Bahjoi meteorites.* Rec. Ge Surv. India, 1936, vol. 71, pp. 144–149, 5 pls.

Accompanied by ' thunder and lightning ' a stone fell at 6.30 p. on March 20, 1934, at Sakamvaripalle, 6 miles SE. of Tirup (13° 38′ N., 79° 25′ E.), Chittor district, Madras. Five pieces a fragments with a total weight of 232 grams were collected. It a light-grey chondrite with olivine, enstatite, probably clinoenstati nickel-iron, and troilite ; sp. gr. 3·603, 3·617. A meteor was observ in the United Provinces at 9.30 p.m. on July 23, 1934, and two da later a siderite was found at Chandankati Muazam (28° 29′ 78° 30½′ E.), 1½ miles NW. of Bahjoi and 9 miles SW. of Moradaba [The locality has been previously incorrectly given as Hapur, Mee district, M.A. **6**–102]. It is a deeply pitted triangular slab weighi 10,322 grams (after being cut in two) ; sp. gr. 7·73. The thin bla crust shows in places lines of flow. It is a coarse octahedrite w a few small patches of troilite. L. J. S.

KHAN (Mohd. A. R.). *The Phulmari, Hyderabad, India, aërolite.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 563–565, 1 fig.

A stone weighing 4064 grams (sp. gr. 3·50) is reported to have ..llen some years ago near the village of Phulmari, about 20 miles NE. of the city of Aurangabad. Spherules of nickel-iron are em-edded in hard stony material. L. J. S.

AKAO (Seizō). *A meteorite which feli at Atsuma-mura, Yūfutsu-gun, Hokkaidō.* (Japanese.) Journ. Geogr., Tokyo Geogr. Soc., 1936, vol. 48, pp. 485–490, 5 figs.

The meteorite was taken from the river immediately after its fall September 3, 1935. A loud thunder-like sound was heard, and e exact position of the fall was shown by a big splash of water. ere was no other pebble in the river. The stone measures 30 × × 15 cm., and weighs 10·69 kg.; sp. gr. 2·87. It is a light-grey eissose rock with pitted surface. Pits as large as peas are seen all er the surface, but none in the interior. It consists of a granular gregate of anhedral crystals of anorthite, olivine, and augite. No rhorhombic pyroxene is present. Analysis gave SiO_2 47·84, Al_2O_3 34, Fe_2O_3 0·71, FeO 2·35, MnO 0·17, MgO 8·49, CaO 13·40, Na_2O 2, K_2O 0·21, P_2O_5 0·32, SO_3 0·50, ign. loss 0·33 = 100·18. R. O.

The composition and structure suggest a gabbro rock; Al_2O_3 is much higher n recorded for a meteoritic eucrite, M.A. 6–396.—L. J. S.]

CROIX (Alfred). *Sur des météorites (aérolithes) trouvées dans le Tanezrouft (Sahara occidental).* Compt. Rend. Acad. Sci. Paris, 1936, vol. 203, pp. 901–903.

Black fragments of two meteorites, evidently belonging to the e fall and broken on reaching the ground, were found in February, 36, on the whitish quartzose gravel of the desert at a spot 10′ N., 0° 5′ E., 135 km. 'NSW.' [i.e. WSW.] of Ouallen. They e some hundreds of metres apart; at one place, over 1 sq. m., ven fragments which fitted together weighed 4849 grams; and at other two pieces, 325 grams, were collected. The density is 59, the fracture grey, and the constituent minerals olivine, nzite, clinobronzite, with a little pigeonite, oligoclase, and merril- ; some pyrrhotine and nickeliferous iron (as kamacite with arrow border of taenite) are also present, Analysis gave SiO_2 6, Al_2O_3 1·99, FeO 10·10, MnO 0·18, MgO 24·52, CaO 1·87, O 0·98, K_2O 0·29, TiO_2 0·32, P_2O_5 0·27, Cr_2O_3 0·32, S 2·05,

Fe 18·88, Ni 1·36, Co 0·04 = '100·38'. The aerolite is classed a a 'chondrite pliosidérifère'. C. A. S.

Oates (Frank). *The meteoric iron of Mbosi.* Tanganyika Notes an Records, Dar es Salaam, 1936, no. 2, pp. 44–49, 2 pls.

A general account of meteorites, with special reference to that c Mbosi. In a moist climate a polished and etched surface soo becomes dull, owing to exudation of lawrencite. [M.M. **22**–487.] L. J. S.

Henderson (E. P.) & Davis (Harry T.). *Moore County, North Carolina, meteorite—a new eucrite.* Amer. Min., 1936, vol. 2 pp. 215–229, 1 fig.

A stone weighing 4 lb. 2 oz. [1860 grams] fell at about 5 p.m. o April 21, 1913, three miles east of Carthage, Moore Co., Nort Carolina (35° 25′ N., 79° 23′ W.). A fireball was seen and a rumblin noise (but no distinct explosion) was heard. A nearly vertical ho two feet deep was made in a freshly ploughed field close to th workers. The stone has a low conical shape with furrows radiating fro the centre. The front surface is covered with a thin (< 1 mm.) lay of transparent dark-brown glass, and the back with a thicker layer opaque black vesicular glass, with a thicker (5 mm.) band around th rim. The interior consists of a friable coarse-grained aggregate of felsp and pyroxene in about equal amounts. The felspar is bytowni (anal. I) with α 1·571, β 1·578, γ 1·583, 2V 77°, negative; extinctio angle on (010) 36°, on (001) 32°. The pyroxene (anal. II, sp. gr. 3·6 was found optically to be of three kinds: (1) hypersthene, with α 1·70 β 1·717, γ 1·720, 2V about 60° variable, negative; (2) pigeonite- with α 1·706, β 1·708, γ 1·730, 2V 0–15°, positive, $\gamma : c = 31$ (3) pigeonite-B, with α 1·693, β 1·696, γ 1·722, 2V 30–40°, positiv $\gamma : c = 38°$. Very little chromite is present, and no metal or sulphi was seen. It is suggested that this eucrite originally consisted bytownite and a single homogeneous pyroxene which on cooli unmixed to give hypersthene and pigeonite, and that at a later da (but not in the earth's atmosphere) the mass was reheated to betwe 1090° and 1510° C. when a portion of the hypersthene was tra

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.	Na_2O.	K_2
I.	46·70	—	33·20	1·59	—	—	0·27	17·42	1·16	0·
II.	49·37	0·62	1·55	1·83	26·44	0·37	15·54	4·60	—	—
III.	48·16	0·32	15·57	1·90	13·98	0·31	8·41	11·08	0·45	0·
IV.	—	—	—	7·53	8·96	—	—	—	0·68	0·

III, also Cr_2O_3 0·44, S 0·30.

rmed into the second variety of pigeonite [cf. M.A. **5**–10]. Analysis is of the complete meteorite, and IV of the glass (n 1·632) of the st. The name Moore County is adopted, since Carthage is pre-upied. L. J. S.

NNIG (Oscar E.) & BROWN (Robert). *The meteorite fall in Oklahoma.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 568–569.

A fireball was observed at 7.7 p.m. on August 17, 1936, over lahoma and parts of Kansas and Texas. It was first seen at ight of about 23 miles travelling at a low angle (11°) in a NW, ection. The final flash and explosion happened at a height of out 13 miles, leaving a cloud that persisted for 15 minutes. yond this terminal point two stones were found a mile apart near scent [Logan Co.]. One found four days later was broken when ived and then weighed 72·7 grams. The other found seven weeks r shows signs of weathering and weighed 5·7 grams. They have hiny black crust and in the interior consist of black crumbly terial with a few white and grey specks and glassy particles; al is sparse. The sp. gr. is very low, 2·0. The stones are probably honaceous chondrites. L. J. S.

NSDALE (John T.). *The Plantersville meteorite, Grimes County, Texas.* Amer. Min., 1936, vol. 21, no. 12, pt. 2, p. [8]. [Abstract.]

A stone weighing 2084·9 grams was recovered a few minutes after fall on the afternoon of September 4, 1930, at 3½ miles SW. of ntersville. Rumbling explosions and a noise like an aeroplane e heard. The light-grey friable material consists of hypersthene, ivine, monoclinic pyroxene, metallic iron, troilite, black and colourless glass, and reddish-brown spinel. Many chondrules are present, st of them angular or fragmental. L. J. S.

NELLA (Vincent P.). *A meteorite from Quartz Mountain, Nevada.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 448–450, 1 fig.

A pitted siderite weighing 4832 grams was found in 1935, on rock beneath two feet of surface detritus, five miles SE. of Quartz ntain. It contains a considerable amount of nickel and traces obalt and copper; sp. gr. 7·67. L. J. S.

Lauterbach (Richard E.). *A new chemical analysis of the Staunto Virginia, siderite.* Popular Astronomy, Northfield, Minneso 1936, vol. 44, pp. 155–156.

Analysis of oxidized shavings of this siderite, found in 1858–9, ga Fe 89·81, Ni 8·41, Co 0·82, Mn trace, Sn 0·17, P 0·21, S 0·02, C 0·(Si 0·03, Cl trace = 99·55. L. J. S.

Nininger (H. H.). *The Bruno meteorite.* Amer. Journ. Sci., 19 ser. 5, vol. 31, pp. 209–222, 7 figs.

This iron, weighing 13 kg., was found in 1931 by a farmer wh clearing his land of rocks at Bruno, Saskatchewan, Canada (52° 16′ 105° 21′ W.). It is slightly oxidized on the surface, but still sho some of the original thin bluish-black fusion crust. Promine 'thumb-marks', groovings, fine flow lines, and small beads shown; and four types of these surface markings are distinguish on different faces, suggesting an oriented flight with a rocking moti Analysis by F. G. Hawley gave Fe 93·30, Ni 5·79, Co 0·29, Cu tra Cr 0·04, P 0·20, S 0·18, Si 0·08. An etched slice shows one pro nent set of parallel lines, resembling taenite, standing out from surface; also a number of parallel sets of sunken Neumann lin These lines are not continued into the outer alteration (heati zones, of which an outer and an inner are shown. Small etching p cover the surface (and also the Neumann lines) giving it a d aspect, but at a certain angle a sheen is shown. Inside these p are seen minute 'bright sharp-angled rhombohedrons' believed to rhabdite [which, however, is tetragonal]. A few small lamellae troilite and schreibersite are present. A flat surface on the m suggests a cleavage plane, and the iron is described as a he hedrite. L. J. S.

Nininger (H. H.). *The Pasamonte, New Mexico, meteorite.* Popu Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 331–3 5 figs.

Further particulars are given of the circumstances of the fall March 24, 1933 [M.A. **6**–105]. Some 70 small, very friable sto with an aggregate weight of about 4 lb. (the largest < 300 gra were collected along a track of 28 miles near Pasamonte in Un Co. The meteor travelled at a very low angle (about $8\frac{1}{2}°$) fr NNE. to SSW. and was last seen at a height of about 17 miles. T track of stones lies four miles north of the plotted path of meteor (a strong south wind was blowing at the time of the fall) a

th its western end ten miles east of the visible end point. The ge and persistent cloud in the stratosphere was no doubt due to e disintegration of the friable material. Many of the small stones ow oriented ridges and flow of glassy material. The meteorite is ssed as a howardite. L. J. S.

NINGER (H. H.). *The meteorite fall of August 10, 1932, near Archie, Cass County, Missouri.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 93–97.

Some further details are given of this fall [M.A. **6**–104]. Detonans were heard, and a trail of smoke 11–14 miles up persisted for -20 minutes. According to some observers there was a rain (like ll) of small particles. L. J. S.

preservation of the Cranbourne meteorite. Nat. Hist. Mag., Brit. Mus., 1936, vol. 5, pp. 381–393, 8 figs.

n account is given of the history of the Cranbourne siderite ich weighs over 3½ tons. Since being received at the British seum in 1865 it has shown considerable rusting. Recently the ss has been cleaned (40 lb. of loose rust removed) and remounted an air-tight glass case through which a steady stream of dry ogen is passed. L. J. S.

N (John D.). *The impact of meteors.* Field & Laboratory, Contr. Sci. Dept. Southern Methodist University, Dallas, Texas, 1936, vol. 4, pp. 56–59.

rom determinations of the slight rise in temperature when rocks crushed by a falling weight, the author argues that the kinetic gy of a falling meteorite is mainly expended in crushing rock in transmitting earthquake waves. This idea is extended to corite craters, where it is believed the heat developed is relatively ll. L. J. S.

N (John D.) & ALBRITTON (Claude C. *Jr.*). *Meteorite craters and their possible relationship to "cryptovolcanic structures".* Field & Laboratory, Contr. Sci. Dept. Southern Methodist University, Dallas, Texas, 1936, vol. 5, pp. 1–8.

he following stages in the fall of a large (100 feet or more across) eorite are considered; (1) passage through the air; (2) impact; explosion. Upon impact the kinetic energy will be transformed heat and into pressure potential energy in rocks subjected to dden pressure of several million atmospheres, which will be

released with explosive violence. Elastic waves in the earth wi produce a central dome surrounded by ring folds, very similar t those found in 'cryptovolcanic structures'. It is suggested th some of the latter are really meteorite craters, and that traces them might be found in rocks of past geological periods. L. J. S.

Öpik (Ernst). *Researches on the physical theory of meteor phenomen I. Theory of the formation of meteor craters* (pp. 3–12). *II. T possible consequences of the collisions of meteors in space* (pp. 1 27). Publications de l'Observatoire Astronomique de l'Unive sité de Tartu [Dorpat], 1936, vol. 28, no. 6, 27 pp.

From the dimensions of the Arizona crater calculations are ma of the work done in (1) penetration and (2) ejecting the crushed roc At impact with cosmic velocity the pressure exceeds the plast limit, and the problem is one of the impact of a liquid drop in a liquid medium with flattening of the projectile. Both metho give a result of about four million tons for the mass of the meteorit Such a mass could not have persisted in one piece. L. J. S.

Watson (Fletcher, *Jr.*). *Meteor craters.* Popular Astronom Northfield, Minnesota, 1936, vol. 44, pp. 2–17, 6 figs.

A review is given of the few known meteorite craters, which a circular in outline, and the view that they are explosion craters supported. More details are given of the shallow and oval Caroli 'bays' [M.A. **5**–303, 408], and the conclusion is drawn that th have no connexion with the fall of meteorites. L. J. S.

Fisher (Clyde). *Meteor Crater, Arizona.* Guide Leaflet, Amer. Mu Nat. Hist., New York, [1936], no. 92, 16 pp., 13 figs.

A reprint with some modifications and additions of a previo popular article [M.A. **6**–105]. L. J. S.

Colvocoresses (George M.). *Meteor crater.* Rocks and Minera Peekskill, N.Y., 1936, vol. 11, pp. 113–117.

A popular account of the Arizona crater and of meteorites general. L. J. S.

Heide (Fritz). *Los cráteres de meteoritos.* Investigación y Progres Madrid, 1934, vol. 8, pp. 176–180, 1 fig.

A review of earlier papers [M.A. **5**–301, 408], with a map of t world showing the distribution of meteorite craters. L. J. S.

ASTAPOVICH (I. S.)] Астапович (И. С.). Метеоритные кратеры на поверхности земли. [*Meteorite craters on the earth's crust.*] Мироведение [Mirovédénie, Bull. Soc. Russ. des Amis de l'Étude de l'Univers), 1936, vol. 25, pp. 92–104.

A review of the literature on meteorite craters, which it is agreed must be explosion craters. L. J. S.

FEß (F. E.). *Zur Deutung des 'Bimssteinvorkommens' von Köfels im Ötztale.* Anzeiger Akad. Wiss. Wien, Math.-naturwiss. Kl., April 30, 1936, reprint 2 pp.

FESS (Franz Ed.). *Der Meteor-Krater von Köfels bei Umhausen im Ötztale, Tirol.* Neues Jahrb. Min., Abt. A, 1936, vol. 72, pp. 98–155, 4 pls., 2 text-figs.

Since 1863 much has been written about a rock basin in shattered gneiss, with scattered blocks and 'pumice', around Köfels in the Ötz valley, Tirol. These accounts and the suggested modes of origin (volcanic or earth movements) are discussed in detail. It is now suggested that here are the relics of a meteorite crater 3–4 km. across, and that the vesicular glassy material enclosing rock fragments is gneiss fused by the fall of a large meteorite. This material, called köfelsite or meteorite-melt (Meteorschmelz), is found as scattered blocks and as a small dike-like mass filling a crevice in gneiss. The age is placed at inter-glacial. L. J. S.

KULIK (L.). *Preliminary results of the meteorite expeditions made in the decade 1921–31.* Popular Astronomy, Northfield, Minnesota, 1936, vol. 44, pp. 215–220, 2 figs. [Cf. M.A. **6**–208.]

Translation of a paper published in 1933 [M.A. **5**–404]. The place of fall on June 30, 1908, of the Tunguska meteorite has not been visited by the author since 1929–30. L. J. S.

SHLEDER (Herbert P. T.). *Lake Bosumtwi, Ashanti.* Geogr. Journ. London, 1936, vol. 87, pp. 51–65, 4 figs.

An examination of this crater lake gives no support to the meteorite crater theory. Volcanic agglomerates have been found. Comparisons are made with the Nördlinger Ries and Steinheim basins. [M.A. 5–150, 301, 409, 410.] L. J. S.

JOHNSON (Douglas). *Origin of the supposed meteorite scars of Carolina.* Science, New York, 1936, n. ser., vol. 84, pp. 15–18.

The 'bays' are associated with sink-holes, and it is suggested that they were lakes formed by sinking following solution of calcareous

beds. The rims consist of wind-blown sands differing in composition from the underlying strata. A book on the subject is promised. [Cf. M.A. **5**-303, 408; **6**-16.] L. J. S.

Martin (R.). *Textieten, hun aard en oorsprong.* [Tektites, their nature and origin.] Natuur en Mensch, Den Haag, 1934, vol. 54, pp. 261–265, 295–298, 16 figs.

A general account and review. Several new determinations of the specific gravity of tektites from various localities suggest that lower values occur in the centre of the areas of distribution. The forms are due to rotation of a fluid mass, and the surface sculpturing to subsequent corrosion. The meteoritic theory is favoured.

L. J. S.

Vogt (Thorolf). *Notes on the origin of the tektites. 1. Tektites as aerial fulgurites.* Kong. Norske Vidensk. Selsk. Forh. Trondhjem, 1935, vol. 8, no. 3, pp. 9–12.

The various views as to the origin of tektites are briefly reviewed and support is given to the bubble theory of E. J. Dunn [M.A. **1**-409; **6**-108], but it is believed that the bubbles were formed by lightning discharges through dust-storms [M.A. **4**-264, **5**-407]. The composition of tektites is compared with that of loess. L. J. S.

Oswald (Jan). *O vzniku povrchu meteorických skel.* [On the origin of the surface of meteoric glasses.] Věda Přírodní, Praha, 1935, vol. 16, pp. 177–184, 1 pl. With discussion by V. Rosicky and F. Slavík, ibid., pp. 288–289.

The author agrees with F. E. Suess [M.A. **5**-406] and F. Hann [M.A. **3**-537] in believing that the surface markings on tektites are primary and due to meteoric corrosion. On one broken tektite (fig. 19) the sculpturing is continuous over the two portions, which fit together. F. S.

Heide (Fritz). *Seltene Elemente in den Tektiten.* Forschungen und Fortschritte, 1936, vol. 12, p. 232.

In the ratio of nickel to chromium the tektites from northern Indo-China (Cr_2O_3 0·012, NiO 0·0035 %) resemble those from Australia whilst those from southern Indo-China (Cr_2O_3 0·03, NiO 0·025) resemble those from Billiton. The amounts of the less-common elements present in tektites are of the same order as in the lithosphere. This gives some support to the theory of their terrestrial origin. [M.A. **6**-19, 108.] L. J. S.

EIDE (F.). *Neue kristallführende Gläser von Macusani in Peru.* Die Naturwissenschaften, 1936, vol. 24, pp. 281–282, 2 figs.

Five rounded pieces (9–375 grams) are transparent to cloudy with ight brownish-green colour, and have d 2·35, n 1·486. They contain nall crystals, and are very similar to the glass from Paucartambo, ru [M.A. **3**–97, 539; **6**–19]. L. J. S.

EYER (H. Otley). *Philippine tektites.* Philippine Magazine, 1935, vol. 32, no. 11, pp. 534, 542–3, 581–2, 1 pl. (Reprint 3 pp.)

A popular account is given of the tektites ('rizalites') [M.A. **4**–422; 18, 160], mostly from Rizal province, which are spherical or lindrical with minutely pitted surfaces. Another variety with tter-like markings, resembling those on billitonites, has been found Busuanga island. More recently, in 1935, at Santa Mesa near nila, typical rizalites have been found in abundance in a red vel overlying volcanic tuff, and associated with tektite-like glasses different types: (1) grey with obsidian structure, (2) brownish- let to rose-pink, (3) greenish-yellow. These are pitted like rizalites t are translucent, and they are compared with the 'americanites' Colombia and Peru [M.A. **6**–19]. L. J. S.

ENIGSWALD (G. H. R. von). *Vorläufige Mitteilung über das Vorkommen von Tectiten auf Java.* Proc. K. Akad. Wetensch. Amsterdam, 1935, vol. 38, pp. 287–289.

Tektites have been found with vertebrate fossils in alluvial gravels Middle Pleistocene age (Trinil beds). They are black, and of ious forms, with small pits on the fresh surfaces. L. J. S.

ASHI (Ryōichi). *A meteorite or a pseudo-meteorite.* (Japanese.) Journ. Geol. Soc. Tokyo, 1936, vol. 43, pp. 407–410, 4 figs.

A peculiar kind of 'tektite' is described which is said to have len at Sakado near Tokyo in 1910. It is subangular and rounded, l weighs 470 grams, and is completely covered with a thin film transparent glass. There are alternating white and dark-coloured ers, the former consisting exclusively of fine-grained aggregates quartz (n 1·55), and the latter almost wholly of colourless glass 1·49). Sp. gr. of the whole stone d_4 2·362, but many pores are sent in the dark bands. Analysis, SiO_2 75·11, Al_2O_3 18·67, Fe_2O_3 4, MgO 0·33, CaO 0·34, Na_2O 4·61, K_2O 0·64, H_2O 0·46 = 100·40, responds with quartz 41·84, albite 38·88, mullite 14·44, orthoclase 8. A fibrous mineral present in the glass as anastomosing streaks

is inferred to be mullite. The rock before the partial fusion supposed to be an albite-quartz-schist. R. O.

X-rays and Crystal-structure.

Hermann (C.), Lohrmann (O.), & Philipp (H.). *Strukturberich Band II, 1928–1932.* Heft 1–4, pp. vii–xxiv, pp. 1–598, 1(figs. Zeits. Krist., 1936, Ergänzungsband II.

Gottfried (C.) & Schossberger (F.). *Strukturbericht, Band II 1933–1935.* Heft 1, pp. 1–160, 276 figs. Zeits. Krist., 193 Ergänzungsband III. [Cf. M.A. **5**–5.]

The parts so far issued deal with inorganic substances; other par are to deal with alloys and organic compounds. Following detail descriptions of different types of structure, abstracts are given papers arranged systematically under elements, compounds A_mBX_4, silicates, &c. L. J. S.

Niggli (P.) & Nowacki (W.). *Strukturbericht: Titelsammlun (1. Januar 1936 bis 1. Juni 1936.)* Zeits. Krist., 1936, vol. 9 pp. 319–336.

This collection of titles of papers on crystal-structure is continu in each of the succeeding parts of the Zeitschrift. L. J. S.

Mauguin (Charles). *Sur la théorie de la réflexion des rayons X p les cristaux.* Compt. Rend. Acad. Sci. Paris, 1936, vol. 2(pp. 1375–1377.

Formulae of reflection of X-rays by non-absorbing crystals a calculated by a new method. F. A. B.

Bragg (W. L.). *Structure-factor graphs for crystal analysis.* Natu London, 1936, vol. 138, pp. 362–363, 2 figs.

Contoured graphs of structure factors have been prepared to a the final stages of determination of crystal-structure. The graphic adjustment of structure factors to agree with observed diffracti intensities is particularly advantageous for substances crystallizi with tetragonal or hexagonal symmetry. F. A. B.

Robertson (J. Monteath). *Calculation of structure factors and su mation of Fourier series in crystal analysis: non-centrosymmetri projections.* Nature, London, 1936, vol. 138, pp. 683–685, 1 f

The description of a simple machine for the calculation of structu factors. Examples of the necessary scales are figured, and t

dvantages of the method especially for complex organic structures e described. F. A. B.

WALD (P. P.) & SCHMID (E.). *Die optische und die Interferenz-Totalreflexion bei Röntgenstrahlen. I.* Zeits. Krist., 1936, vol. 94, pp. 150–164, 11 figs.

CHMID (Erich). ——. *II.* Ibid., pp. 165–196, 10 figs.

The optical total reflection and interference total reflection of X-ys by a crystal plate are defined. The Fresnel formula for reflec-on is only approximately true for small glancing angles. A more mplete mathematical treatment is derived, and data for calcite lculated from the new formulae are given. F. A. B.

HEN (M. U.). *The elimination of systematic errors in powder photographs.* Zeits. Krist., 1936, vol. 94, pp. 288–298, 6 figs.

—— *The calculation of precise lattice constants from X-ray powder photographs.* Ibid., pp. 306–310.

Lattice dimensions calculated from X-ray powder photographs are ble to errors due to absorption and eccentricity of the sample and m shrinkage. A method is developed for eliminating these errors phically, providing the X-ray beam enters rather than leaves the indrical camera through the middle of the film. The second per shows how to minimize the necessary computations and how select an optimum set of diffractions. F. A. B.

ND (F.). *Vergleich der elektrostatischen Energien einiger Ionengitter.* Zeits. Physik, 1935, vol. 94, pp. 11–21, 2 figs.

Madelung numbers and the corresponding Coulomb energies are alculated for lattices of the following types: nickel arsenide, boron ride, cuprite, β-tridymite, β-cristobalite, β-quartz, and for chain d molecular lattices. It is found that for lattices in which the ordination numbers of the constituent ions are well defined the tice energy is dependent on the co-ordination numbers alone. grams are given showing the relation between the energy of a en lattice type and ionic sizes. F. A. B.

UGEBAUER (Th.). *Über die Elektronenleitung und die Gitterstabilität binärer Kristalle.* Zeits. Physik, 1935, vol. 95, pp. 717–733, 8 figs.

The calculated polarization energies of binary compounds are atest for those compounds which possess the smallest Coulomb rgies. The electrical conductivity is least for compounds of the

caesium chloride and rock-salt type, rises to a maximum for cor pounds of the nickel arsenide type, and disappears in molecul lattices. F. A. B.

Burgers (W. G.). *Electron-diffraction photograph of a random arrang ment of "cross-grating crystallites"*. Zeits. Krist., 1936, vol. 9 pp. 301–305, 3 figs.

Electron-diffraction photographs of very thinly etched, rolled, ar recrystallized nickel-iron strip show, superposed upon the sing crystal spot-pattern, powder-rings sharply limited on the inside b diffuse outwards. The phenomena agree with von Laue's predictic of the diffraction effects to be expected from a random arrangement two-dimensional crystallites or cross-gratings. Photometer measur ments of the photograph indicate the presence of a hexagonal cros grating with side-length of the unit rhomb 3·08 Å. The nature the material forming the cross-grating remains undetermined.

F. A. B.

Kratky (O.) & Krebs (G.). *Die Verwendung von Konvergenz- u Schwenkaufnahmen zur Herstellung von Schichtliniendiagramme* Zeits. Krist., 1936, vol. 95, pp. 253–265, 6 figs.

A continuation of an earlier paper [M.A. **5**–19] on methods overcoming the difficulties involved in taking X-ray photographs small or badly formed crystals. H. H.

Ieviņš (A.) & Straumanis (M.). *Experimentelle oder rechnerisc Fehlerelimination bei Debye-Scherrer-Aufnahmen.* Zeits. Krist 1936, vol. 94, pp. 40–52, 1 fig.

Experimental precautions are described by means of which t Debye-Scherrer method can be used to give lattice-constants wi a high degree of accuracy. They were applied to thallium chlori (a 3·8331 ± 0·0003 Å. at 18° C.), arsenious oxide (a 11·0497 ± 0·0008 with Cu-K radiation and 11·0493 ± 0·0008 with Cr radiation at 23° C. and lead nitrate (a 7·8401 ± 0·0004 Å. with Cu radiation and 7·8406 ± 0·0005 Å. with chromium radiation at 22·5° C.). H. H.

Valenkov (N.) & Poray-Koshitz (E.). *X-ray investigation of t glassy state.* Zeits. Krist., 1936, vol. 95, pp. 195–229, 19 figs.

The authors took X-ray photographs of various specimens c crystalline and vitreous silica, and also of soda-silica glasses wit varying percentages of soda and silica at different temperatures, i order to discriminate between the crystallite hypothesis and B. H

arren's theory of a continuous non-crystalline atomic network [I.A. **5**–470]. They conclude that the crystallite hypothesis is rrect. H. H.

URGERS (W. G.) & JACOBS (F. M.). *Crystal structure of β-titanium.* Zeits. Krist., 1936, vol. 94, pp. 299–300.

β-Titanium, stable above about 900° C., has a body-centred cubic ructure with two atoms in the unit cell of edge *a* 3·32 Å.

L. J. S.

AVES (F.) & WERNER (St.). *Zur Kristallstruktur von Mg_2Zn_{11} und dessen Isomorphie mit $Mg_3Cu_7Al_{10}$.* Zeits. Krist., 1936, vol. 95, pp. 114–128, 2 figs.

The Laue symmetry of Mg_2Zn_{11} (often taken as $MgZn_5$) is O_h. The it cell contains three molecules and has *a* 8·53 Å. The compound $_3Cu_7Al_{10}$ has a similar structure with *a* 8·29 Å. H. H.

EVEL (Ludo K.). *The crystal structure of ammonium azide, NH_4N_3.* Zeits. Krist., 1936, vol. 94, pp. 197–211, 7 figs.

Ammonium azide has the space-group D_{2h}^7. The unit cell contains r molecules of NH_4N_3 and has *a* 8·930, *b* 8·642, *c* 3·800 Å.

H. H.

RAY-SZABÓ (St. v.). *Röntgenographische Untersuchung des Aluminium-12-borids AlB_{12}.* Zeits. Krist., 1936, vol. 94, pp. 367–374.

Commercial 'crystallized boron' consists largely of two kinds of stals with formula AlB_{12} having diamond and graphite habit pectively. The former is tetragonal or orthorhombic pseudo-agonal. The unit cell contains sixteen molecules of AlB_{12} and *a* 12·55, *c* 10·18 Å. H. H.

ELMHOLZ (Lindsay). *The crystal structure of the low temperature modification of thallous iodide.* Zeits. Krist., 1936, vol. 95, pp. 129–137, 2 figs.

Thallous iodide occurs in a red modification stable above 175° C., l in a yellow modification stable below that temperature but ning green on exposure to light. The yellow form has the space-up D_{2h}^{17}. The unit cell contains four molecules of TlI and has ·24, *b* 4·57, *c* 12·92 Å. H. H.

BERSTEIN (A.). *Etude sur le bromure double de cuivre et d'ammonium.* Bull. Soc. Franç. Min., 1936, vol. 59, pp. 329–337, 5 figs.

Copper ammonium bromide $CuBr_2.2NH_4Br.2H_2O$ crystallizes as en tetragonal prisms (110) terminated by the bipyramid (101).

The unit cell with dimensions a 7·98, c 8·41 Å. contains two molecule and the calculated specific gravity is 2·81, agreeing well with tl observed value 2·82. The bromide is isomorphous with and has tl same crystal-structure (space-group D_{2h}^{14}) as the correspondir chloride. [M.A. **4**–103.] F. A. B.

MacGillavry (C. H.) & Bijvoet (J. M.). *Die Kristallstruktur v Zn(NH$_3$)$_2$Cl$_2$ und Zn(NH$_3$)$_2$Br$_2$.* Zeits. Krist., 1936, vol. 9 pp. 249–255, 1 fig.

The salts Zn(NH$_3$)$_2$Cl$_2$ and Zn(NH$_3$)$_2$Br$_2$ have a similar structu They belong to the space-group D_{2h}^{28}. The unit cell contains fo molecules and has a 7·78, b 8·50, c 8·08 Å. for the chloride and a 8·1 b 8·81, c 8·41 Å. for the bromide. H. H.

Aminoff (Brita). *Über die Kristallstruktur von K$_2$ReCl$_6$.* Zeit Krist., 1936, vol. 94, pp. 246–248, 1 fig.

The structure of K$_2$ReCl$_6$ is of the K$_2$PtCl$_6$ type. The space-grou is O_h^5. The unit cell contains one molecule and has a 9·861 Å. wi u 0·240. H. H.

McCullough (James D.). *The crystal structure of potassium chlor mate K$_2$OsCl$_6$, and of potassium bromosmate, K$_2$OsBr$_6$.* Zei Krist., 1936, vol. 94, pp. 143–149, 5 figs.

Potassium chlorosmate and potassium bromosmate have t ammonium chloroplatinate structure with four molecules in t cubic unit cell and a 9·729, 10·30 Å., respectively. H. H.

Buerger (M. J.). *Crystals of the realgar type: the symmetry, u cell, and space group of nitrogen sulphide.* Amer. Min., 19 vol. 21, pp. 575–583.

The unit cell, a 8·78, b 7·14, c 8·645 Å., β 87° 39′, contains 16N space-group C_{2h}^5. This is believed to be isostructural with realg [M.A. **6**–169], although the cell dimensions are markedly differen L. J. S.

Finch (G. I.) & Wilman (H.). *The diffraction of electrons by mol denite.* Trans. Faraday Soc., 1936, vol. 32, pp. 1539–15 3 pls., 5 text-figs.

Taking a 3·15 Å. [M.A. **2**–196], the axial ratio c/a of molybdenite 3·904. L. J. S.

AY (K.). *Die Kristallstruktur des Rubidium-Sulfids Rb_2S.* Zeits. Krist., 1936, vol. 94, pp. 412–413.

The space-group of rubidium sulphide is probably O_h^5. The unit l contains four molecules of Rb_2S and has an edge 7·65 Å.

H. H.

NDQVIST (Märta), LINDQVIST (Dick), & WESTGREN (A.). *The crystal structure of Co_9S_8 and of pentlandite $(Ni,Fe)_9S_8$.* Svensk Kemisk Tidskrift, 1936, vol. 48, pp. 156–160, 1 fig.

The formulae Co_4S_3 and Co_6S_5 are improbable. Material containing atomic % S still shows the (111) line of metallic cobalt, whilst that 48 % shows lines of CoS. Co_9S_8 has a 9·907 Å., d 5·24, with $4Co_9S_8$ the unit cell; space-group O_h^5. Pentlandite from Sudbury, Ontario, es the same pattern with a 10·02 Å. Artificial $Fe_9Ni_9S_{16}$ has 10·09 Å. and $Fe_6Ni_3S_8$ 9·91 Å. L. J. S.

ERGER (M. J.). *The symmetry and crystal structure of the minerals of the arsenopyrite group.* Zeits. Krist., 1936, vol. 95, pp. 83–113, 8 figs.

The determination of the structure of arsenopyrite is subject to cial difficulties. No orthorhombic structure fits the data and the ior gives a monoclinic or triclinic pseudo-orthorhombic structure, unit cell having its angles all right angles and a 9·51, b 5·65, ·42 Å. and containing eight molecules of FeAsS. H. H.

RKER (David). *The application of the three-dimensional Patterson method and the crystal structures of proustite, Ag_3AsS_3, and pyrargyrite, Ag_3SbS_3.* Journ. Chem. Physics (Amer. Inst. Physics), 1936, vol. 4, pp. 381–390, 6 figs.

roustite gave a 10·74, c 8·64 Å., and pyrargyrite a 11·04, c 8·71 Å., h six molecules in the unit cell; space-group C_{3v}^6. By a simplifica- n of the Patterson method of Fourier analysis (Zeits. Krist., 1935, . 90, p. 517) the positions of the heavy atoms are fixed.

L. J. S.

HMOND (Wallace E.). *Crystallography of livingstonite.* Amer. Min., 1936, vol. 21, pp. 719–720, 1 fig.

Minute flexible needles from Huitzuco, Mexico, gave $a:b:c =$ 572 : 1 : 5·3660, $\beta = 75° 50'$, with the forms c(001), a(100), d(101), 1), $p(\bar{1}11)$, q(122), and doubtful $(\bar{1}\bar{1}.1.0)$, (011), (111), $(\bar{1}22)$. The

crystals are elongated along the *b*-axis and have perfect (001) cleav age. X-ray photographs give a unit cell, *a* 15·14, *b* 3·98, *c* 21·60 Å containing $4(HgSb_4S_7)$; space-group C_{2h}^5. L. J. S.

Buerger (M. J.). *Crystallographic data, unit cell and space group fo berthierite* ($FeSb_2S_4$). Amer. Min., 1936, vol. 21, pp. 442–448.

Weissenberg photographs of the striated needles of berthierit from Kisbánya [Min. Mag. **23**–566] gave a unit cell *a* 11·44, *b* 14·1 *c* 3·76 Å. ($a:b:c = 0{\cdot}810:1:0{\cdot}266$), containing four molecul $FeSb_2S_4$, and space-group C_{2v}^9 or V_h^{16}. L. J. S.

Kołaczkowska (Marja). *La cellule fondamentale du quartz et de l calcédoine.—O komórce elementarnej kwarcu i chalcedonu.* Arch Min. Tow. Nauk. Warszaw. (Arch. Min. Soc. Sci. Varsovie 1936, vol. 12, pp. 82–85 (French), pp. 86–89 (Polish), 1 pl 1 text-fig.

Specimens of chalcedony (sp. gr. 2·625) from Janowa Dolin Volhynia, Poland, quartz of aqueous origin from Dauphiné, an quartz of igneous origin from the granite of Tatra, Poland, giv powder photographs identical in pattern, but yielding different uni cell measurements and therefore calculated axial ratios and specif gravities. [Sp. gr. calculated from the data as given suggests son error.]

	c.	*a.*	*c*/*a.*	*d.*
Chalcedony	5·275	4·718	1·117	[2·40]
Quartz (aqueous)	5·393	4·903	1·099	[2·65]
Quartz (igneous)	5·430	4·964	1·093	[2·74]

F. A. B.

Náray-Szabó (St. v.). *Zur Struktur des Baddeleyits* ZrO_2. Zeit Krist., 1936, vol. 94, pp. 414–416.

Using the observations of K. Yardley [Min. Mag. **21**–168], th author determines the co-ordinates of the ions in baddeleyite as 4Z in 000, $0\frac{1}{2}\frac{1}{2}$, $\frac{1}{2}\frac{1}{2}0$, $\frac{1}{2}0\frac{1}{2}$; $4O_I$ in 0·200, 0·220, 0·210; and $4O_{II}$ i 0·288, 0·750, 0·210. H. H.

Ketelaar (J. A. A.). *Crystal structure and shape of colloidal particl of vanadium pentoxide.* Nature, London, 1936, vol. 137, p. 31 —— *Die Kristallstruktur des Vanadinpentoxyds.* Zeits. Krist., 193 vol. 95, pp. 9–27, 3 figs.

Crystals of artificial V_2O_5 separated from the fused material a orthorhombic; the unit cell containing $2V_2O_5$ has dimensions *a* 11·4

$4{\cdot}36_0$, c $3{\cdot}55_5$ Å., space-group C_{2v}^7. The structure contains deformed tetrahedra VO_4, arranged in chains along the c-axis by sharing corners and in planes parallel to (010). The structure is in accordance with the observed cleavage (010) > (100) > (001). Colloidal V_2O_5 contains ribbon-shaped particles, elongated along the [001] axis and flattened parallel to (010). F. A. B.

GARRIDO (J.). *Sur la brucite fibreuse.* Zeits. Krist., 1936, vol. 95, pp. 189–194, 5 figs.

Fibrous brucite (nemalite) has the same structure as ordinary brucite, the unit cell having a 3·125, c 4·752 Å. The c-axes of the constituent crystals are perpendicular to the length of the fibre but except for this limitation have no definite orientation. On heating, the nemalite passes into cubic MgO. H. H.

GARRIDO (Jules). *Sur la déshydratation de la brucite.* Compt. Rend. Acad. Sci. Paris, 1936, vol. 203, pp. 94–95.

X-ray examination of the changes in structure in a crystal of brucite when dehydrated to MgO shows that at 500° C. it passes into an aggregate of small crystals of MgO, the majority of which are so oriented that their axes [111] and [110] coincide with [0001] and [$\bar{1}$10] of brucite, and the axes a, b, c retain the same orientation as the Mg–(OH) bonds of brucite; the rest have the same arrangement but rotated through 180° around [111], or within 10° thereof. At 700° to 1000° there are slight indications of a further change in structure. C. A. S.

GOLDSZTAUB (S.). *Quelques observations sur la boehmite.* Bull. Soc. Franç. Min., 1936, vol. 59, pp. 348–350, 1 pl.

Artificial monohydrate of aluminium, AlO(OH), assumed to be identical with boehmite, yields a powder photograph very similar to that of lepidocrocite. The unit-cell dimensions deduced on the assumption that the lines on both the photographs have the same indices are a 3·78, b 11·8, c 2·85 Å. [M.A. **6**–176.] F. A. B.

GRUNER (M. J.). *The symmetry and crystal structure of manganite, Mn(OH)O.* Zeits. Krist., 1936, vol. 95, pp. 163–174, 7 figs.

Manganite is monoclinic (pseudo-orthorhombic), with space-group up $B2_1/d$. The unit cell contains eight molecules of Mn(OH)O and has a 8·86, b 5·24, c 5·70 Å., β 90°. H. H.

Büssem (W.) & Eitel (A.). *Die Struktur des Pentacalciumtrialumina* Zeits. Krist., 1936, vol. 95, pp. 175–188, 5 figs.

Pentacalcium trialuminate should be given the formu $12CaO.7Al_2O_3$ rather than $5CaO.3Al_2O_3$. The space-group is T_d^6 a the unit cell contains two molecules with a 11·95 Å. H. H.

Wyart (Jean). *Réseau cristallin et macles de la leucite.* Com Rend. Acad. Sci. Paris, 1936, vol. 203, pp. 938–939.

X-ray examination of leucite from Frascati shows it to be tet gonal, the unit cell having a 12·95, c 13·65 Å., and containi $16KAlSi_2O_6$; space-group D_4^{10} ($I4_12$). Above 600° C. the crystals a cubic. On cooling they become tetragonal with the quaterna axis along one or other of the directions [100], [010], or [00 Rotation of the crystals around [111] shows further twinning arou this axis of pseudo-symmetry. The structure closely resembles t of analcime $NaAlSi_2O_6.H_2O$ which is pseudo-cubic with a 13·7 [Cf. Min. Mag. **22**–471.] C. A. S.

Elg (Sven). *Die Gitterkonstante von Topas.* Zeits. Physik, 19 vol. 101, pp. 113–116.

The distance between atomic planes parallel to the cleavage (0 is 4186·97 X. [i.e. 4·18697 Å. This is apparently to be used a constant in X-ray spectroscopic analysis, but the kind and compo tion of the topaz are not stated.] L. J. S.

Strunz (Hugo). *Die chemische Zusammensetzung von Pollucit.* Zei Krist., 1936, vol. 95, pp. 1–8, 1 fig.

Pollucite has the space-group O_h^{10}. The unit cell contains ei molecules of $Cs_2(Si_4Al_2O_{12}).H_2O$ and has a 13·71 Å. The mineral affinities with leucite and analcime. H. H

Kokkoros (P.). *Über die Gitterkonstanten und die Raumgruppe Lievrits.* Die Naturwissenschaften, 1936, vol. 24, p. 619.

The unit cell of ilvaite has dimensions a 8·76, b 13·04, c 5·82 Å., a contains four molecules $CaFe_2(FeOH)(SiO_4)_2$; space-group V_h^{16}. L. J. S

Hendricks (Sterling B.). *Concerning the crystal structure of kaolin $Al_2O_3.2SiO_2.2H_2O$, and the composition of anauxite.* Zeits. Kri 1936, vol. 95, pp. 247–252, 2 figs.

Measurements were taken to test J. W. Gruner's suggested str ture for kaolinite, on which doubts had been thrown [M.A. **5**–1

4]. They were in accordance with Gruner's theory. The increase the $SiO_2 : R_2O_3$ ratio in anauxite above that required for the rmula $Al_2O_3.2SiO_2.2H_2O$ was found to be due to subtraction of luminium ions and hydroxyl groups rather than to replacement of by Si. H. H.

PPARENT (Jacques de). *Sur l'interprétation des radiogrammes de poudres de cristaux exécutés d'après les phyllites argileuses.* Compt. Rend. Acad. Sci. Paris, 1936, vol. 203, pp. 596–599.

The variations in the spacings indicated in the powder photographs these phyllites (kaolinite, halloysite, attapulgite, &c.) are discussed, t no definite conclusion is arrived at. It is suggested that they are least partially due to varying water content. C. A. S.

AUS (Otto). *Untersuchungen über das Kristallgitter von Heteropolysäuren und deren Salzen. 3. Mitteilung. Beitrag zur Kenntnis der Isomorphieerscheinungen und der strukturellen Beziehungen bei den höheren Hydraten von Heteropolyverbindungen.* Zeits. Krist., 1936, vol. 94, pp. 256–279.

Writing for short (H_3P, 24) instead of $H_3PW_{12}O_{40}.24H_2O$, &c., the hor gives the structures of (H_3P, 24), (Li_3HSi, 24), (FeHSi, 24), HSi, 24), (Ba_2Si, 24), (Li_3HSi, 26), (Ca_2Si, 26), (Zn_2Si, 27), (Cu_2Si, 27), Si, 27), (AlHSi, 28), (FeHSi, 28), (CrHSi, 28), (ThSi, 30), &c., which all rhombohedral substances having the space-group D^5_{3d} and a unit l containing two molecules. The edge of the cell varies between ·80 and 16·47 Å., while its angle varies between 56° 10′ and 59° 30′. e substances are compared with another group of closely allied ts crystallizing in the cubic system, namely, $H_3PW_{12}O_{40}.29H_2O$, $PMo_{12}O_{40}.30H_2O$, $FeHSiW_{12}O_{40}.30H_2O$, $NdPMo_{12}O_{40}.30H_2O$, and $_2SiW_{12}O_{40}.31H_2O$. H. H.

RPER (J. P.). *Crystal structure of sodium carbonate monohydrate, $Na_2CO_3.H_2O$.* Zeits. Krist., 1936, vol. 95, pp. 266–273, 1 fig.

Sodium carbonate has the orthorhombic space-group $2e$–5. The t cell contains four molecules of $Na_2CO_3.H_2O$ and has a 10·721, ·440, c 5·243 Å. H. H.

OOSTER (W. A.). *On the crystal structure of gypsum, $CaSO_4.2H_2O$.* Zeits. Krist., 1936, vol. 94, pp. 375–396, 8 figs.

The results published by E. Onorato [M.A. **4**–158] are criticized l a new structure is assigned to gypsum with space-group C^6_{2h}. H. H.

Lipson (H.). *The crystal structure of $3CdSO_4.8H_2O$.* Proc. Roy. Soc London, Ser. A, 1936, vol. 156, pp. 462–470, 3 figs.

The unit cell of dimensions a 9·44, b 11·87, c 16·49 Å., β 62° 44' contains four molecules of $3CdSO_4.8H_2O$. The space-group is C_{2h}^6 and 38 parameters define the structure. L. J. S.

Łaszkiewicz (Antoni). *Über die Struktur des Syngenits.—O strukturz syngenitu.* Arch. Min. Tow. Nauk. Warszaw. (Arch. Min. Soc Sci. Varsovie), 1936, vol. 12, pp. 8–11 (Germ.), pp. 12–13 (Polis summary), 1 pl.

Rotation photographs of syngenite from Kałusz [M.A. **3**–549] gav a unit cell a 9·70, b 7·15, c 6·20 Å., β 76°, containing two molecule $K_2SO_4.CaSO_4.H_2O$, and space-group C_{2h}^2. L. J. S.

Miller (J. J.). *The crystal structure of anhydrous sodium chromat Na_2CrO_4.* Zeits. Krist., 1936, vol. 94, pp. 131–136, 1 fig.

The space-group of sodium chromate is D_{2h}^6. The unit cell contair four molecules of Na_2CrO_4 and has a 5·91, b 9·23, c 7·20 Å. H. H.

Peyronel (Giorgio). *Struttura del pirofosfato di uranio: UP_2O* Zeits. Krist., 1936, vol. 94, pp. 311–312.

The space-group of uranium pyrophosphate is T_h^6. The unit ce has edge 8·61 Å., and contains four molecules of UP_2O_7. The stru ture is similar to that of the pyrophosphates of Si, Ti, Zr, Sn, Hf. H. H.

Strunz (H.). *Vergleichende röntgenographische und morphologisch Untersuchung von Andalusit $(AlO)AlSiO_4$, Libethenit $(CuOH)CuP$ und Adamin $(ZnOH)ZnAsO_4$.* Zeits. Krist., 1936, vol. 9 pp. 60–73, 5 figs.

Libethenite and adamite have the space-group D_{2h}^{12}. The unit ce contains four molecules, and has, respectively, a 8·08, b 8·43, c 5·90 Å and a 8·32, b 8·54, c 6·08 Å. The two minerals are isomorphic an are isotypic to andalusite. H. H.

Machatschki (F.). *Die Kristallstruktur von Tiefquarz SiO_2 un Aluminiumorthoarsenat $AlAsO_4$.* Zeits. Krist., 1936, vol. 9 pp. 222–230, 1 fig.

The space-group of aluminium arsenate is D_3^4 or D_3^6. The un cell contains three molecules of $AlAsO_4$, and has a 5·03, c 11·22 Å the density being 3·34. A comparison is made with the structu of quartz, which was redetermined for this purpose as previou determinations were not consistent with each other. H. H.

WELLS (A. F.). *The crystal structure of silver diammino-tetranitro-cobaltiate* ($Ag[Co(NH_3)_2(NO_2)_4]$). Zeits. Krist., 1936, vol. 95, pp. 74–82, 4 figs.

The space-group of the crystals is D_{4h}^4. The tetragonal unit cell contains two molecules and has a 6·97, c 10·43 Å. H. H.

KRIEL (M. van) & VERWEEL (H. J.). *Über die Struktur der Tripelnitrite.* Zeits. Krist.. 1936, vol. 95, pp. 308–314, 1 fig.

Out of some fifty compounds of the form $A_2BM(NO_2)_6$ discussed by Ferrari and his collaborators, the authors select $(NH_4)_3Co(NO_2)_6$, $K_3Co(NO_2)_6$, $K_2CaNi(NO_2)_6$, $K_2PbCu(NO_2)_6$ for a detailed investigation. Their space-group is T_h^3, and the edge of the unit cell 10·78, 10·46, 10·34, 10·65 Å., respectively. H. H.

RANKUCHEN (I.). *Structure of silver uranyl acetate.* Zeits. Krist., 1936, vol. 94, pp. 212–221, 6 figs.

Silver uranyl acetate has the space-group C_{4h}^6. The unit cell contains 16 molecules and has a 12·98, c 28·10 Å. H. H.

Rock-forming Minerals and Petrology.

[NEMOVA (Z. N.) & LEVINSON-LESSING (F. Y.)] Немова (З. Н.) под ред. Левинсон-Лессинг (Ф. Ю.). Сборник анализов русских изверженных и метаморфических горных пород.—Compilé par Z. NÉMOVA et rédigé par F. LOEWINSON-LESSING. *Recueil d'analyses chimiques des roches éruptives et métamorphiques russes.* Труд. Геол. Комитета (Mém. Comité Géol.), 1930, n. ser., no. 186, 361 pp.

A tabulated collection of 1676 published chemical analyses of rocks, giving, besides weight percentages, the molecular ratios and molecular percentages of the several oxides, and the Levinson-Lessing, Niggli, and Grubenmann values, and references to the literature. There is no index or guide, and the grouping of the analyses is not obvious. L. J. S.

GOLDING (E.) & PHAUP (A. E.). *Chemical analyses of the rocks, ores and minerals of Southern Rhodesia.* Bull. Geol. Surv. Southern Rhodesia, 1936, no. 29, 105 pp. Price 6*s*.

This valuable collection contains 76 analyses of fresh igneous rocks, 63 of altered and metamorphosed igneous rocks, 75 of sediments and metamorphosed sediments, and 113 of minerals and ores. The analyses are the work of E. Golding, and each analysis is

accompanied by a brief description of the corresponding rock l A. E. Phaup. The normative symbols (but not the actual norm which might have been added with advantage) are tabulated at t end of the volume. S. J. S.

[Ginsberg (A. S.) & Nikogosyan (Khr. S.)] Гинсберг (А. С.) Никогосян (Хр. С.). Опыты сплавления диабаза с гранитом. Ginsberg (A.) et Nikogossian (Chr.). *Essais de fusion de diabase et du granite.* Изв. Геол. Ком. (Bull. Géol. Comm Leningrad, 1924, vol. 43, pp. 735–765, 1 fig. (Russian wi French summary.)

Powdered diabase and alkali-granite mixed in various proportio were fused in an electric furnace (1400° C.). The resulting produ in all cases was a homogeneous black glass. An approximate linear variation of the refractive indices and specific gravities of t glasses suggests that they are isotectic mixtures. The coexisten of two liquid magmas and also of liquid-magmatic differentiati are questioned. S. I. T.

[Ginsberg (A. S.) & Nikogosyan (Khr. S.)] Гинсберг (А. С.) Никогосян (Х. С.). Опыты сплавления диабаза с углекисл кальцием. [*The experiments of fusion of diabase with carbon of lime.*] Изв. Акад. Наук СССР (Bull. Acad. Sci. URSS), 19 pp. 679–696, 1 fig.

A small addition of $CaCO_3$ to diabase resulted in the formation homogeneous glass on cooling of the mixture. With 25 % CaC diopside microlites appeared in the glass, and further addition $CaCO_3$ resulted in the formation of skeletal crystallites and microli of melilite (n 1·648). With 50 % and more of $CaCO_3$ a granul mineral suggesting calc-olivine made its appearance. Melts wi more than 64 % $CaCO_3$ disintegrated on cooling into a granul powder suggesting the transformation of β-Ca_2SiO_4 into γ-Ca_2SiO_4 S. I. T.

[Ginsberg (A. S.) & Karandashev (N. M.)] Гинзберг (А. С.) Карандашев (Н. М.). О применении Калагеранского базал для литья.—Ginsberg (A.) und Karandašev (N.). *Der Ka geranbasalt als Gussmaterial.* Труд. Петр. Инст. Акад. На СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1931, no. pp. 5–20, 1 pl.. 5 text-figs. (Russian with German summary

INSBERG (A. S.)] Гинзберг (А. С.). Базальты с. Бобрица (Украина) с точки зрения их пригодности для литья.—GINSBERG (A. S.). *Basalte des Dorfes Bobriza (Ukraine) vom Gesichtspunkt ihrer Tauglichkeit bei der Giesserei.* Ibid., 1933, no. 4, pp. 83–89. (Russian with German summary.)

The experiments on the fusion of basalts in an electric furnace re conducted with a view to ascertain their suitability for casting electrical insulators and other technical objects. The basalt from lageran (Armenia) with SiO_2 49·91 proved to be a very suitable terial for this purpose, while the basalt from Bobriza with SiO_2 79 was too viscous. The fusion was conducted at 1250–1350° C., d the cast product was glassy. By annealing at 850° C. one could ain either a fine-grained porcelain-like material, or a coarser terial, almost exactly reproducing the original basalt. [Cf. M.A. 00.] S. I. T.

NSBERG (A. S.)] Гинзберг (А. С.). К вопросу о взаимоотношениях между силикатами и сульфидами.—GINSBERG (A. S.). *Zur Frage über das gegenseitige Verhältnis zwischen Silikaten und Sulphiden.* Труд. Петрогр. Инст. Акад. Наук СССР (Trav. Pétrogr. Inst. Acad. Sci. URSS), 1933, no. 4, pp. 21–44, 21 figs. (Russian with German summary.)

study of the binary systems Fe_2SiO_4–FeS, $MnSiO_3$–FeS and SiO_4–FeS. Rapid chilling of the melts shows a gravitational ration of the silicate and sulphide portions as two immiscible id layers. Slow cooling produces a crystalline eutectic structure he two portions. The influence of the thermal history on the e of formation of ores is emphasized. S. I. T.

SHTERLY (М. К.)] Бельштерли (М. К.). Опыты нагревания гранита. *Experiments of heating of granite.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1934, no. 6, pp. 393–398, 1 pl. (Russian with English summary.)

ne observations made on the minerals of granite, heated (for two s at a time) at regular intervals between 550° and 1500 C., are llows. (1) Orthoclase, at 1100° the optic axial angle decreases ro and the optical axial plane changes its position, melting at °. (2) Plagioclase, becomes turbid at 1100° and melts between ° and 1340°. (3) Quartz, begins to fissure at 550°, at 1340° rushes in convergent light are markedly bent, at 1500° passes cristobalite. (4) Biotite, at 550° becomes brownish along the

edges, at 1100° changes into an ore substance, at 1240° begins melt. S. I. T.

[Belikov (B. P.)] Беликов (Б. П.). О составе некоторых горел пород Кузбасса.—Belikov (B. P.). *Über die Zusammensetzu "Brandiger Gesteine" des Beckens von Kusnetzk (Kusbass).* Тр. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. S URSS), 1933, no. 4, pp. 91–100, 8 figs. (Russian with Germ summary.)

Certain shales and argillaceous sandstones from Kusnetzk co basin were found baked, fused, and recrystallized by the heat burning underground coal seams [cf. M.M. **23**–207]. The high altered rocks contain the following minerals: quartz, tridymi cristobalite, mullite, cordierite, green spinel, magnetite, felsp nepheline, fayalite, pyroxene, mica, chlorite, and glass. S. I. T.

[Zavaritzky (A. N.)] Заварицкий (А. Н.). О псевдолейцитовых эпилейцитовых горных породах.—Zavarickij (A.). *On pseu leucitic and epileucitic rocks.* Докл. Акад. Наук СССР (Com Rend. Acad. Sci. URSS), 1934, vol. 3, pp. 645–648 (Russia 648–651 (English), 2 figs.

The author proposes the term *epileucite* as applied to orthocla muscovite pseudomorphs after leucite, as distinct from pseudoleuc (orthoclase + nepheline). It is suggested that epileucite is form during the hydrothermal stage, and pseudoleucite during the m matic stage. Epileucite-porphyry, resembling leucite-porphyry fr Loch Mheallain, Assynt, described by S. J. Shand, was found Ishim river (West Siberia). Two types of this rock are distinguish The first is a melanocratic rock with epileucite phenocrysts embedd in a fine-grained fluidal groundmass composed of minute orthocl laths and biotite. The analysis of this rock gave: SiO_2 52·94, TiO_2 0· Al_2O_3 21·32, Fe_2O_3 1·29, FeO 2·82, MnO 0·15, MgO 0·71, CaO 3· Na_2O 4·04, K_2O 8·37, CO_2 1·67, H_2O+ 3·12, H_2O- 0·22 = 100· The second type is a leucocratic rock with a granular groundm free from biotite. In one slide pseudomorphs of jarosite after pyr were found. S. I. T.

[Vorobieva (O. A.)] Воробьева (О. А.). Об одном плагиоклазов пегматите. *On one plagioclase pegmatite.* Труд. Петр. Ин Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 19 no. 6, pp. 45–51, 1 pl., 1 text-fig. (Russian with Engl summary.)

The hypersthene-quartz-diorite of Volchia tundra, Kola [M.A. 6–113], is cut by several andesine-pegmatite dikes. The dike rock contains phenocrysts of a reddish andesine-antiperthite (α 1·5411, β 1·5452, γ 1·5487, 2V 87°, negative), which on analysis by V. A. Egorov, gave SiO_2 60·87, TiO_2 0·05, Al_2O_3 23·55, Fe_2O_3 0·24, FeO 0·32, MnO 0·01, MgO 0·23, BaO 0·06, CaO 4·68, Na_2O 7·38, K_2O 1·49, H_2O- 0·38, ign. loss 0·56 = 99·82. The groundmass consists of andesine and biotite (α 1·6052, $\beta = \gamma$ 1·6308, 2V very small, pleochroic), which on analysis gave SiO_2 41·15, TiO_2 5·15, Al_2O_3 15·33, Fe_2O_3 2·50, FeO 11·90, MnO 0·04, MgO 10·95, BaO 0·12, CaO 0·87, Na_2O 1·29, K_2O 7·54, H_2O- 1·01, ign. loss 2·40 = 100·25.

S. I. T.

IGNATIEV (N. A.)] Игнатьев (Н. А.). Амфиболиты, гранатовые гедрититы и слюдиты окрестностей с. Шуерецкого. *Amphibolites, garnet-gedritites and micaites from outskirts of s.* [*village*] *Shueretsky.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1934, no. 6, pp. 65–82, 1 pl., 8 text-figs. (Russian with English summary.)

Intrusions of granite and pegmatite of post-Botnian age into the amphibolites of Karelia gave rise to zones of intense metamorphism with formation of garnet-gedritites and garnet-micaites (garnet-biotite-rocks). In their chemical composition these rocks do not greatly differ from the original amphibolites. Garnet is mainly almandine-pyrope and it is also developed in the pegmatites, some crystals reaching 25 cm. in diameter; five analyses are given. Gedrite is found as radial aggregates of dark-green crystals (α 1·642, β 1·648, γ 1·658, $\gamma : c = 0–3°$, 2V 78°, positive) which on analysis give SiO_2 46·50, TiO_2 0·89, Al_2O_3 15·48, Fe_2O_3 0·89, FeO 16·01, MnO nil, MgO 17·62, CaO 0·81, Na_2O 0·77, K_2O 0·12, ign. loss 1·19 = '99·78', sp. gr. 3·223.

S. I. T.

KUPLETSKY (B. M.) & OKNOVA (T. M.)] Куплетский (Б. М.) и Окнова (Т. М.). Количественно-минералогический состав нефелиновых пород. *Quantitative mineralogical composition of nepheline rocks.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1934, no. 6, pp. 17–28, 1 pl., 2 text-figs. (Russian with English summary.)

This is a preliminary account of the classification of plutonic nepheline-bearing rocks by means of statistical methods. By plotting

352 modal analyses on various diagrams certain types were recog nized as dominant and their averages calculated, as follows :

	Felspar.	Nepheline.	Coloured minerals.	Accessory minerals.
Nepheline-syenite	60·4	20·0	19·61	
Ijolite	—	45·72	37·73	16·55
Urtite	—	82·67	9·93	7·40

The felspar-free nepheline-rocks are classified, according to the pe centages of nepheline, as follows :

0–35 %, jacupirangite and melteigite ; 35–60 %, ijolite ; 60–75 % sundry rare rocks ; over 75 %, urtite.

The relation of nepheline to felspar (24·9 : 75·1) in the avera nepheline-syenite is similar to that of quartz to felspar (26 : 74) the granite eutectic, and it is suggested that nepheline-syenite magn may also represent an anchi-eutectic solution derived from an ac magma. S. I. T.

[Lupanova (N. P.)] Лупанова (Н. П.). Базальтическая рогов обманка и авгит из мончикита Хибин. *Basaltic hornblende a augite from monchikite of Hibina mountains.* Труд. Петр. Ин Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 193 no. 6, pp. 53–64, 1 pl. (Russian with English summary.)

One of the dikes cutting chibinite in Khibina tundra is compos of dark monchiquite (anal. I) with phenocrysts of hornblende (4 vol. %, anal. II), and idiomorphic augite (13·5 vol. %, anal. III) i fine-grained or glassy groundmass. Analyses by O. N. Kobylina.

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.	Na_2O.	K
I.	42·33	2·19	13·66	3·18	8·39	0·46	8·91	11·65	4·84	2
II.	39·57	4·19	16·29	7·13	1·56	0·21	14·92	9·32	3·48	1
III.	47·44	1·48	3·41	8·66	1·88	0·15	14·12	22·37	0·06	0

	H_2O-.	Ign.	Total.	α.	β.	γ.	γ:c.	2V.
I.	0·31	2·22	100·35	—	—	—	—	—
II.	0·23	0·84	'99·73'	1·662	1·684	1·697	13°	77°
III.	0·16	0·94	100·68	1·695	1·700	1·713	43°	60½°

S. I. T.

[Zavaritzky (A. N.)] Заварицкий (А. Н.). Северная группа вулкан Камчатки. [*The northern group of Kamchatka volcanoes.*] C Изуч. Прир. Рес., Сер. Камчатская, Вып. I, Акад. Наук CC (Counc. Research Natur. Res., Kamchatka Ser., no. 1, Acad. S USSR), 1935, 55 pp., 19 figs.

Altogether there are in Kamchatka 126 volcanoes. The volcanicity began in the Pliocene, and at least 15 volcanoes are still active. The present paper gives a review of the northern group of volcanoes situated around Klyuchevskaya Sopka. The majority of lavas are andesites, but basalts are also found. A number of new data is given including several chemical analyses. S. I. T.

[Zavaritzky (A. N.)] Заварицкий (А. Н.). Вулкан Авача на Камчатке и его состояние летом 1931 г.—Zavaritsky (A. N.). *Avacha volcano and its state in 1931.* Труд. Центр. Научно-Иссл. Геол.-Разв. Инст. (Trans. Centr. Geol. & Prosp. Inst.), Leningrad, 1935, no. 35, 36 pp., 7 figs. (Russian with English summary.)

The volcanic group of Avacha is situated 35 km. NNE. of Petropavlovsk in Kamchatka. The principal cone is of the Somma-Vesuvius type, and since its last activity in 1926 it remains in the fumarolic stage. The lavas, eighteen analyses of which are given, are mainly represented by basalt and andesite. The analyses of fumarolic gases show abundant H_2O (up to 95 %), the remainder consisting of HCl, SO_2, H_2S, and CO_2. Thirty-six analyses of fumarolic incrustations show the predominance of sulphate of aluminium, then of iron and magnesium. The chief minerals of the incrustations are: alunogen, halotrichite, pickeringite, voltaite, gypsum, thenardite. Incrustations of sulphur, marcasite, and veins of gypsum and anhydrite are also found. S. I. T.

[Zavaritzky (A. N.)] Заварицкий (А. Н.). Некоторые вулканические породы окрестностей Ключевской сопки на Камчатке.—Zavaritsky (A. N.). *Some igneous rocks from the environs of Kliuchevskaia Sopka (Kamchatka).* Зап. Росс. Мин. Общ. (Mém. Soc. Russe Min.), 1931, ser. 2, vol. 60, pp. 153–236, 16 figs. (Russian with English summary.)

Klyuchevskaya Sopka is the largest active volcano in Kamchatka. A detailed microscopical description and six chemical analyses of the lavas are given. They comprise basalt (anal. I), andesito-basalt, olivine-augite-andesite (II), sanidine-andesite, augite-hypersthene-andesite, hornblende-pyroxene-andesite, and hornblende-andesite (III). A comparison is made between the volcanic rocks of Kamchatka and those of Kurile Islands, Japan, and other regions.

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.
I.	52·17	1·10	17·77	3·08	6·40	0·18	5·16
II.	55·31	0·62	20·97	1·95	3·84	0·09	3·37
III.	60·72	0·35	18·19	2·28	3·54	0·09	2·56

	CaO.	Na_2O.	K_2O.	P_2O_5.	H_2O+.	H_2O-.	Total.
I.	8·96	2·82	1·07	1·28	1·20	0·06	100·25
II.	7·50	3·27	1·93	0·30	0·49	0·02	99·66
III.	6·29	3·92	1·57	0·18	0·64	—	100·34

S. I. T.

[Petrov (V. P.)] Петров (В. П.). "Микролакколиты" окрестнос г. Тифлиса.—Petrov (V. P.). *Die Mikrolakkolithe in d Umgegend der Stadt Tiflis.* Труд. Петр. Инст. Акад. Наук СС (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1933, no. 3, pp. 79–8 6 figs. (Russian with German summary.)

The 'micro-laccolites' are small hemispherical swellings (10 cn 2 m. in diameter) of thin dikes and complete spheroids (3–50 cm. diameter) connected to the dikes by thin stringers. The dikes the selves emanate from a thin sill injected into bedded tuffs and shal The intrusive rock is yellowish-brown in colour and is composed an aggregate of laumontite (α 1·513, γ 1·524, 2V 31°, negative) chalcedony and opal 30, chlorite 10–15, and felspar 5–10 %. T felspar is highly zeolitized. The chemical analysis of the rock V. A. Moleva is: SiO_2 66·03, TiO_2 0·66, Al_2O_3 15·46, Fe_2O_3 1· FeO 0·72, MnO 0·04, MgO 0·59, CaO 5·75, Na_2O 0·44, K_2O 1·22, i loss 8·00 = '100·33'. S. I. T

[Belyankin (D. S.)] Белянкин (Д. С.). К петрографии Среднего Ура —Beliankin (D.). *To the petrography of Middle Urals.* Тр Главн. Геол. Разв. Упр. СССР (Trans. Geol. Prosp. Serv USSR), 1931, no. 56, pp. 47–62, 2 pls., 1 map. (Russian w English summary.)

The intrusive alkali rocks of the Kyshtym and Kaslinsk regi are described. They form the northern extension of the alkali b of the Ilmen Mts. [M.A, 2–170] and are represented by miask soda-syenite, and granite. Certain rocks, such as felspar-amphibo with hastingsite, soda-quartzite, lestiwarite, and syenite, are c sidered to be the connecting links with the granite-gneisses of region. The possibility of granite palingenesis and the desilificat of the acid magma by the ultra-basic rocks is suggested. Seve analyses are given. S. I. T

[Belyankin (D. S.)] Белянкин (Д. С.). К петрографии Поморского берега Белого моря.—Beljankin (D. S.). *Zur Petrographie der pomcrischen Küste des Weissen Meeres.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1932, no. 2, pp. 103–114, 2 pls., 1 text-fig. (Russian with German summary.)

Besides a description of the prevalent rocks (gneiss, granite, and amphibolite) of the SW. coast of the White Sea an account is given of a gabbro-diabase dike intrusive into granite at Cape Medvezhy. Under the influence of basic magma the granite has undergone partial refusion with the production of a fine-grained material, cementing corroded components of granite and also infilling cracks in the granite. The contact effect on gabbro-diabase is marked by the development of micropegmatite, biotite, hornblende, scapolite, calcite, and garnet. The plagioclase of the gabbro-diabase shows a marked clouding. S. I. T.

[Kupletsky (B. M.)] Куплетский (Б. М.). Геологические наблюдения в северной Карелии летом 1929 г.—Kupletskij (B. M.). *Geologische Beobachtungen in Nord-Karelien.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1932, no. 2, pp. 73–96, 2 pls., 3 text-figs. (Russian with German summary.)

The geology of the area to the north-west of Kandalaksha Bay, White Sea, is described. The dominant rocks are various gneisses (muscovite-garnet, scapolite-hornblende, kyanite), cut by veins of muscovite-pegmatite. Near Fedoseevka are found dikes of calcite-bearing analcime-augitite, which are probably genetically connected with the alkali complex of Turya peninsula [M.A. **6**–305, 306].

S. I. T.

[Kupletsky (B. M.)] Куплетский (Б. М.). К изучению диабазовых пород Новой Земли.—Kupletskij (B. M.). *Zur Erforschung der Diabasgesteine von Novaja Zemlja.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1932, no. 2, pp. 5–15, 1 fig. (Russian with German summary.)

The basic intrusions and effusions of Upper Devonian age in the south island of Novaya Zemlya are typical diabases, with or without olivine. They are often epidotized and in some places have deposits of native copper associated with them. The rocks of the north island are mainly albite-diabases associated with picrites. It is suggested that albite-diabase and picrite are the products of

differentiation of diabase magma represented by the rocks of t south island. Several analyses are given. S. I. T.

[Belyankin (D. S.) & Vlodavetz (V. I.)] Белянкин (Д. С.) Влодавец (В. И.). Щелочной комплекс Турьего мыса.—Be jankin (D. S.) und Vlodavec (V. I.). *Der alkalische Gestei komplex des Kaps Turij.* Труд. Петр. Инст. Акад. Наук СС (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1932, no. 2, pp. 45–7 3 pls., 5 text-figs. (Russian with German summary.)

This is a continuation of the previous work on the alkali rocks Turya peninsula, Kola [M.A. **6**–305, 306]. Three periods of intrusi are distinguished. First period: (1) alkali-basalt, (2) calcitiz eruptive breccia, (3) carbonatite. Second period: (1) ijolite, (2) turjai (3) turjite, (4) melanocratic aegirine-syenite, (5) carbonatite. Thi period: (1) alkali-basalt, (2) melilite-basalt, (3) augitite, (4) nephe nite, (5) carbonatite. All the rocks of these series, with the excepti of syenite, are considered to be derived from an alkali magma ri in volatiles, so that the last products of crystallization of ea period were almost pure calcite rocks. The syenite, which is e tremely variable in composition, and passes into ijolite on one si and into contact sandstone on the other, is considered to be t product of interaction between the ijolitic magma and the sandsto The normal unaltered sandstone (anal. I) is composed of clas quartz and felspar in an argillaceous-calcareous paste. The syenitiz sandstone is greatly enriched in alkalis, and two contrasted types a distinguished: albite-syenito-sandstone (anal. II), composed of alb 81·5, hornblende 12·4, aegirine 1·7, calcite 3·5, and magnetite 0· and orthoclase-syenito-sandstone (anal. III), composed of orthocl

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.
I.	72·06	0·49	9·62	3·66	0·42	0·18	2·13	2.81
II.	65·21	0·30	17·56	1·54	0·46	0·08	0·31	1·91
III.	62·88	0·34	15·57	1·52	0·76	0·10	1·21	0·97
IV.	24·60	0·29	3·61	1·91	6·79	0·30	3·90	31·11

	Na_2O.	K_2O.	CO_2.	H_2O+.	H_2O-.	Total.
I.	2·31	2·41	2·92	0·12	0·26	99·39*
II.	10·00	1·11	1·37	0·16	0·09	100·10
III.	3·61	11·80	—	0·61	0·18	99·55
IV.	1·75	0·44	9·58	0·67	0·45	99·79†

* I, incorrect Fe_2O_3 '0·66', total '99·36' in the original.

† IV, also P_2O_5 12·30, Cl 0·05, F 1·80, S 0·24; FeO 6·79 omitted from origin total less O for F, &c. = 99·03.

0·9, albite 11·5, hornblende 15·1, magnetite 0·2, and an unknown llowish mineral 2·3. A variety of an almost felspar-free syenite represented by the calcitic-aegiapite [cf. M.A. **4**–220], composed calcite, aegirine, and apatite (anal. IV). S. I. T.

AVLOVSKY (E. V.) & TZVETKOV (A. I.)] Павловский (Е. В.) и Цветков (А. И.). Материалы к петрографии траппов (Юго-западная часть Тунгусского бассейна).—*Contribution to petrography of traps* (*S.W. part of Tungussky basin*). Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1934, no. 6, pp. 293–316, 3 pls., 1 text-fig. (Russian with English summary.)

The gabbro-diabase sills and dikes of the river Tunguska are markably uniform both in their mineral and in their chemical mposition (ten analyses are given), and are similar to the rocks scribed by F. Y. Levinson-Lessing and others [M.A. **6**–317]. The jority of them are composed of hortonolite ($\gamma - \alpha$ 0·036–0·044, gative, 2V 60–78°), monoclinic pyroxene, labradorite, with alkali-agioclase of the second generation, iron ore, and accessories. Some vines are zonal with an iron-rich outer rim. S. I. T.

ELIKOV (B. P.) & KUZNETZOV (S. S.)] Беликов (Б. П.) и Кузнецов (С. С.). О габбровой интрузии на северовосточных склонах Триалетского хребта.—BELIKOV (B. P.) and KUZNEČOV (S. S.). *On the gabbro intrusion on north-eastern slope of Trialetsky range.* Труд. Петр. Инст. Акад. Наук СССР (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1934, no. 6, pp. 141–157, 1 pl., 5 text-figs. (Russian with English summary.)

A sheet intrusive into Eocene sediments of Transcaucasia shows marked variety of composition, due probably to differentiation. e contact facies (anal. I) are porphyritic (phenocrysts of labra-rite) with a fine-grained groundmass. The main body of the

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	BaO.	CaO.
	50·16	0·76	20·56	2·24	4·47	0·13	3·39	0·32	7·43
	47·94	0·80	19·75	3·53	3·46	0·14	4·56	0·13	9·76
	47·61	0·74	13·66	3·65	5·26	0·17	11·29	0·12	10·75

	Na_2O.	K_2O.	H_2O-.	Ign. loss.	Total.
I.	3·01	3·70	0·92	3·54	'100·33'
II.	2·97	2·54	0·46	3·84	99·88
III.	1·91	1·75	0·41	2·85	100·17

intrusion is an alkali-gabbro (essexite) (anal. II), composed of lab dorite (+orthoclase), biotite, augite, magnetite, and analcime. T central part is olivine-gabbro (anal. III) with fresh olivine, bioti labradorite, augite, and magnetite. The contact sandstone is stron albitized and prehnitized. (Analyses by V. A. Egorov). S. I. T

[Sokolov (G. A.)] Соколов (Г. А.). Щелочный метасоматоз в ам болитах горы Верблюжьей. *Alkaline metasomatism in amp bolites of Verbliugjia Mnt.* Труд. Петр. Инст. Акад. Наук СС (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1934, no. 6, pp. 179–1 2 pls., 3 text-figs. (Russian with English summary.)

Certain facies of amphibolite xenoliths in the peridotite-serpent massif of Verblyuzhaya Mtn. (south Ural), composed of hastings albite, andesine, natrolite, and cancrinite, are explained as the p ducts of metasomatism of amphibolite by 'granitic fluides wh have passed through the bulk of serpentines and peridotites'.

S. I. T

Miscellaneous.

[Vardanyantz (L. A.)] Варданянц (Л. А.). К минералогии Садонс жилы. (Центральный Кавказ).—Vardanianz (L. A.). *Mineralogie des Ssadon-Erzganges (Zentraler Kaukasus).* Всеросс. Мин. Общ. (Mém. Soc. Russe Min.), 1934, ser. 2, vol. pp. 481–483. (Russian with German summary.)

The mineral from Sadon mine previously placed in the hum group [M.A. 6–366] is nearer to knebelite according to its crysta graphical and optical properties. It is of a dark green colour (alm colourless in thin section), prismatic habit (orthorhombic?) wit perfect (100) and imperfect (010) and (001) cleavages. Its opti properties are $1{\cdot}78 < \alpha < 1{\cdot}85$, $\gamma - \alpha\, 0{\cdot}036$, 2V $50° \pm 5°$, optics negative, dispersion and pleochroism slight. S. I. T

[Petrov (V. P.)] Петров (В. П.). Материалы к изучению мес рождений серы в Трусовском ущелье.—Petrov (V. P.). *Mate lien zur Erforschung der Schwefellagerstätten in der Trusso Schlucht (Kaukasus).* Труд. Петр. Инст. Акад. Наук СС (Trav. Inst. Pétrogr. Acad. Sci. URSS), 1933, no. 3, pp. 89– (Russian with German summary.)

The sulphur deposits of Trusov gorge (central Caucasus) are forn by sulphur springs. Gypsum and keramohalite are produced by

action of these springs on shale. Keramohalite is found as snow-white radial aggregates in sheltered parts of the outcrop. Its composition is Al_2O_3 15·98, Fe_2O_3 0·02, FeO 0·85, MgO 0·79, SO_3 36·93, H_2O 42·39, insoluble 2·58 = 99·54. Its optical properties are: α 1·479, γ 1·490, $\gamma : c = 28°$. S. I. T.

[Ikornikov (N. Y.) & Sevryugin (E. A.)] Икорников (Н. Ю.) и Севрюгин (Е. А.). Пирамидальные, но призматического габитуса кристаллы оловянного камня из Восточного Забайкалья.—Ikornikow (N. U.) and Sevrjugin (E. A.). *Pyramidal crystals of tinstone of prismatic form from east Transbaikal.* Зап. Ленинград. Горн. Инст. (Ann. Inst. Mines Leningrade), 1934, vol, 8, pp. 175–176, 2 figs. (Russian with English summary.)

Crystals of cassiterite from pegmatite veins at Zavitinsky are elongated along a polar edge of the pyramid (111) and are either simple or twinned on (101). This prismatic habit is characteristic of low-temperature pegmatites. L. J. S.

[Grigoriev (D. P.)] Григорьев (Д. П.). Изучение магнезиально-железистых слюд.—Grigoriev (D. P.). *Study of magnesium-iron micas.* Зап. Всеросс. Мин. Общ. (Mém. Soc. Russe Min.), 1935, vol. 64, pp. 21–79, 12 figs. (Russian with English summary.)

Chemical analyses with dehydration curves and optical data are given for nine phlogopites from the Slyudyanka deposits in Baikalia. Pure magnesia-mica and others containing iron or nickel were prepared in fusions with fluorite. Refractive indices increase with the percentage of iron. In micas of the first class (optic axial plane $\perp$ (010)) 2E increases up to about 5 % Fe and then decreases; in those of the second class 2E decreases with increasing iron. The general formula is written $MX_3Y_4O_{10}.mA$ or

$$(K,H)(Mg,Fe'',Mn)_3(Si,Al,Fe''')_4O_{10}.0\text{–}3(OH,F).$$

Analyses are plotted in a cubic diagram with the fluor molecules $F_2KMg_3AlSi_3O_{10}$ (fluor-phlogopite), $F_2KFe_3''AlSi_3O_{10}$ (fluor-annite), $F_2KMg_3Fe'''Si_3O_{10}$ (fluor-meroxene), and $FeKFe_3''Fe'''Si_3O_{10}$ (fluor-siderophyllite) at four corners, and the corresponding hydroxyl molecules ($(OH)_2KMg_3AlSi_3O_{10}$, hydroxyl-phlogopite, &c.) at the remaining four corners. L. J. S.

Jirkovský (Rudolf). *Otázka dimorfismu recentního uhličitanu vápe natého v příbramiských dolech.* [The question of the dimorphism of recently formed calcium carbonate in the mines of Příbram] Věda Přírodní, Praha, 1936, vol. 17, pp. 165–168.

Small stalactites and crystalline crusts, now forming on timber &c., in the mine galleries, consist mainly of aragonite. Analysis of the alkaline mine waters show the presence of $MgSO_4$, which is responsible for the deposition of the metastable modification. In some cases this may perhaps also be due to the presence of Ba, Sr, Pb, and in the deeper (1200 m.) parts of the mines to the higher temperature. F. S.

Kokta (Jaroslav) & Němec (František). *Granát ultrabasických hornin od Černína.* [Garnet of the ultrabasic rocks of Černín.] Věda Přírodní, Praha, 1936, vol. 17, pp. 176–180, 5 figs.

A garnet from pyroxenic eclogite from Černín, southern Moravia, gave optical data in perfect accord with the chemical composition SiO_2 41·97, TiO_2 0·24, Al_2O_3 21·73, Cr_2O_3 0·72, Fe_2O_3 2·36, FeO 6·17, MnO 0·97, MgO 20·45, CaO 5·52, H_2O 0·02 = 100·15, sp. gr. 3·668.

λ ...	670·8 (Li).	589·3 (Na).	535·1 (Tl).	492·5 (He).	460·8 (Sr).	447·2 (He)
n ...	1·7348	1·7385	1·7424	1·7481	1·7495	1·7519

F. S.

Goll (Jaroslav J.). *Chalkografický výzkum dobšinského gersdorffitu.* [Metallographic investigation of gersdorffite from Dobšiná] Příroda, Brno, 1936, vol. 29, pp. 220–222, 1 fig.

The nickel arsenide ore from Dobšiná, Slovakia, shows on polished sections white and violet components, mixtures of the two being pale violet. Crystals showing a zonal structure are white in the centre and violet on the outer portion. The violet component seems to contain less sulphur. F. S.

Bobková (*Miss* B.). *Regular growth of orthoclase and quartz from Striegau in Prussian Silesia.* (*Zákonný srůst orthoklasu a křemene od Striegau v Pruském Slezsku.*) Spisy vydávané přírodovědeckou fakultou Masarykovy University (Publ. Fac. Sci. Univ. Masaryk) Brno, 1935, no. 204, 18 pp., 4 figs. (English.)

A crystal of orthoclase shows seven crystals of quartz, all approximately parallel, projecting from different faces. On its broken surface

he crystal grades into graphic granite. Goniometric measurements show that a pair of prism faces and the *c*-axis of the quartz crystals are approximately parallel to (010) of the orthoclase, with the *c*-axes of the two minerals inclined at about 45°. Further, the zone [*rzs*] of the quartz coincides approximately with the [001] zone of the orthoclase, the deviation being $\frac{3}{4}$–5°. This orientation corresponds nearly with that described by G. Rose (1837 'Rose's law'). Other orientations described in the literature are critically examined. [M.A. **2**–63.] L. J. S.

UITZOW (Hans Wilhelm). *Pumpellyit, ein häufiges Hydrothermal- und Sekundärmineral in basischen Gesteinen.* Zentr. Min., Abt. A, 1936, pp. 39–46, 2 figs.

The presence of pumpellyite is recognized by its high refraction (*n* 1·68–1·69) and characteristic pleochroism (*α* colourless to pale brownish-yellow, *β* deep bluish-green, *γ* colourless to pale yellowish) in micro-sections of diabase and diabase-porphyrite from several localities in Germany, Siberia, Corsica, and Calabria. It is of hydrothermal origin in amygdales or of secondary origin from calcium silicates, and occurs associated with chlorite, epidote, and prehnite. Another mode of occurrence of the mineral is with lawsonite in glaucophane-schists. [M.A. **5**–233, 479.] L. J. S.

HÜRMANN (H. M. E.). *Lawsonit aus Cuba.* Zentr. Min., Abt. A, 1936, pp. 245–251, 5 figs.

Lawsonite occurs as snow-white veins in xenoliths of chlorite-schist in serpentine in province Santa Clara. Needles of the mineral are also embedded in calcite and in the groundmass of the rock. Polysynthetic twinning is shown; *n* 1·666–1·68, sp. gr. 3·056, H. 6. Analysis by van Tongeren gave SiO_2 37·80, TiO_2 0·69, Al_2O_3 32·56, Fe_2O_3 0·05, FeO 0·34, MnO trace, MgO 0·32, CaO 16·10, Na_2O 0·51, K_2O 0·24, H_2O+ 11·26, H_2O- 0·04, F 0·02 = 99·93, agreeing with $H_4CaAl_2Si_2O_{10}$. L. J. S.

ILLIET (V.) & JONG (W. F. de). *Over kasoliet.* Natuurwetenschappelijk Tijdschrift, Gent, 1936, vol. 18, pp. 261–265, 1 fig. (Flemish with French résumé.)

New goniometric measurements of kasolite gave $a : b : c = 1·8953 : 1 : 0·9575$, $\beta = 75°\ 18'$ [M.A. **3**–371]. Determination of water gave 2·2–3·3 %, corresponding with the new formula $PbO.UO_3.SiO_2.H_2O$

[M.A. **1**–249]; sp. gr. 6·46. The unit cell, of dimensions a 13·
b 7·01, c 6·71 Å., β 75°, contains four of these molecules. L. J. S

Billiet (V.). *Het uranotielvraagstuk.* [The uranotile proble
Natuurwetenschappelijk Tijdschrift, Gent, 1936, vol. 18, p. 7
X-ray examination shows that uranotile is orthorhombic and i
morphous with sklodowskite. The formula $CaO.2UO_3.2SiO_2.6H$
is also confirmed. L. J. S

Watanabe (Takeo). *Crystals of native tellurium from Japan.* Jou
Fac. Sci. Hokkaidô Univ. Sapporo, Ser. 4, 1936, vol. 3, pp. 1(
111, 1 pl., 8 text-figs.
Crystals of tellurium occur in vugs in gold-silver veins in ande
of late Tertiary age in the Kawazu (Rendaizi) mine, Izu [M.A. **5**–4
and the Teine mine, Sapporo [M.A. **5**–285]. At Kawazu they
associated with rhodochrosite, inesite, tellurite, and rickardite; a
at Teine with gold, tetrahedrite, and baryte. The minute (0·3–0·7 m
crystals were adjusted on the goniometer with the aid of a binocu
microscope and an auxiliary light source. They are hexago
prisms with r and r_1, and gave $a:c = 1:1{\cdot}3310$ and $1:1{\cdot}3302$
the two localities respectively. L. J. S

Gallitelli (P.). *Sulla babingtonite di Baveno.* Atti (Mem.) S
Toscana Sci. Nat., 1935, vol. 45, pp. 178–191, 4 figs.
Nine crystal-forms were observed on crystals of babington
a 1·713–1·716, β 1·725–1·728, γ 1·747–1·750, $\gamma:a = 32$–33°, $a:c =$ 4
Analysis gave SiO_2 52·34, TiO_2 nil, Al_2O_3 1·58, Fe_2O_3 15·55, FeO 7·
MnO 1·77, MgO trace, CaO 19·25, Na_2O 0·30, K_2O 0·06, $H_2O(+11$
1·18 = 99·81. Sp. gr. 3·342. L. J. S

McConnell (Duncan). *Spherulitic concretions of dahllite from Ishawo
Wyoming.* Amer. Min., 1935, vol. 20, pp. 693–698, 3 figs.
Small balls occurring in beds of Upper Cretaceous age have
internal spherulitic structure of plumose fibres and consist essentia
of dahllite (carbonate-apatite, $Ca_{10}CO_3(PO_4)_6$), with ω 1·635, ϵ 1·6
They are compared with the dahllite and podolite of phospho
nodules from other localities. L. J. S

Goßner (B.) & Drexler (K.). *Römerit von Pfaffenreuth, Ob
Zentr. Min., Abt. A, 1935, pp. 267–270.
Dark-brown stalactitic römerite occurs with several other sulpha
in a pyrite deposit. Analysis, SO_3 38·40, Al_2O_3 1·45, Fe_2O_3 19·

eO 8·78, MgO 0·14, CaO 0·62, H_2O 30·98 = 99·92, agrees only pproximately with the formula $Fe''Fe'''_2(SO_4)_4.14H_2O$.

L. J. S.

AMDOHR (Paul). *Bertrandit von Klein-Spitzkopje, Südwestafrika.* Zentr. Min., Abt. A, 1936, 257–262, 5 figs.

Minute crystals of bertrandite (sp. gr. 2·599) are associated with iartz, orthoclase, albite, tourmaline, chalybite, and fluorite (but no eryl), all the minerals being encrusted with limonite and hyalite. he crystals are tabular with hemimorphic development, and show e new forms (320), (304), (308), (104), (114), and (134) [$a:b:c$ = 5688 : 1 : 0·5973]. L. J. S.

AGNER (P.). *Über einen Japaner Zwilling von Crummendorf in Schlesien.* Zeits. Krist., 1936, vol. 93, pp. 409–410, 2 figs.

A specimen of quartz from Crummendorf is described, consisting two individuals twinned on the Japan law, each of which is shown etching to be itself a twin. H. H.

DNNAY (J. D. H.). *Système de grilles pour la détermination des minéraux.* Ann. (Bull.) Soc. Géol. Belgique, 1936, vol. 59, pp. B 250–B 257.

A series of cards with perforations corresponding to various aracters are superposed. [Cf. M.A. 1–339.] L. J. S.

SÀRO [i.e. CESÀRO] (G.) & MÉLON (J.). *Sur la cryolite : indice de réfraction, biréfringences et formes cristallines.* Bull. Cl. Sci. Acad. Roy. Belgique, 1936, 362–372, 3 figs.

From the index of refraction on c (1·338 yellow) and the birefrinnce on c (0·00059) and m (0·00077), $\gamma - \alpha$ is calculated as 0·001135. ven crystal-forms are noted, including u ($\bar{2}75$) [Dana's axes].

L. J. S.

APLES (Lloyd W.). *Mineral determination by microchemical methods.* Amer. Min., 1936, vol. 21, pp. 613–634, 13 figs.

The chemical elements are identified by means of crystalline cipitates. Several new tests are described. L. J. S.

RNADSKY (W.). *Sur la classification des gaz naturels.* Bull. Soc. Franç. Min., 1934, vol. 57, pp. 338–358.

A plea for the inclusion of natural gases in mineralogical classifican and study. F. A. B.

Bannister (F. A.) & Plenderleith (H. J.). *Physico-chemical examination of a scarab of Tuthmosis IV bearing the name of god Aten.* Journ. Egyptian Archaeology, London, 1936, vol. pp. 3–6, 2 pls.

In order to determine the genuineness of a scarab, comparati tests were made on authentic scarabs and on steatite from Göpfe grün, Bavaria. The natural mineral had n 1·570, sp. gr. 2·76, H. baked at 900° C. for one hour it lost 2·5 %, and then had n 1·5 sp. gr. 2·81, H. 7, and gave a different X-ray pattern (viz. that enstatite). Spectrographic analysis of remnants of the decompos glaze on the scarab showed the presence of copper. It is conclud that the steatite in which the scarab was carved was baked at abo 900° C. L. J. S.

Butterfield (J. A.). *Outgrowths on zircon.* Geol. Mag. Lond 1936, vol. 73, pp. 511–516, 11 figs.

A few of the minute (0·1 mm.) rounded crystals of zircon pres in the Millstone Grit of the Pennines show pyramidal growths the sides of the prism, producing saw-like edges. The origi crystals are colourless, purple, dusky, or yellow, but the seconda growths are always colourless. L. J. S.

Wilcox (Ray). *An occurrence of large zircon needles in a ba pegmatite.* Amer. Min., 1936, vol. 21, p. 459.

Crystals of brown zircon (ω 1·925, ϵ 1·979) up to $7\frac{1}{4}$ inches lo and $\frac{1}{16}$–$\frac{1}{8}$ inch across penetrate crystals of plagioclase, hornblen and biotite in gabbro-pegmatite near Mellen, Wisconsin. L. J. S.

Rutherford (Ralph L.). *Optically positive cordierite in the Kisse new gneiss at Sherridon, Manitoba.* Amer. Min., 1936, vol. pp. 386–388.

Macroscopic grains of blue, optically positive cordierite are asso ated with garnet and metallic sulphides in parts of the rock. [M.A. **6**–188.] L. J. S.

Murdoch (Joseph). *Adamite from Chloride Cliff, California.* Am Min., 1936, vol. 21, pp. 811–813, 3 figs.

Small colourless crystals from the oxidized zone are equi mensional or elongated along the a-axis; forms $a\,h\,m\,l$, e(01 α 1·720, β 1·740, γ 1·745 +, 2V 90° ±. L. J. S.

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